LOGIC

HIGHER SECONDARY
SECOND YEAR

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HIGHER SECONDARY – SECOND YEAR

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I. THE LOGICAL CHARACTERISTICS OF TERMS

A proposition has two terms, subject and predicate. Terms perform logical function of conveying meaning. A term has the following characteristics:

1. A logical term is either a *noun or a noun clause.*

2. A logical term may consist of a *single word or many words.* Single-worded terms : Examples, Mahatma, tree, man, etc. Many-worded terms: Examples, The author of the Gita, an intelligent student, the University of Madras, etc.

3. A logical term is either *univoral or equivocal.* A term is univocal if it has only one clear meaning. A term is equivocal if it has more than one meaning. The word ' vice ' for example, is equivocal because it means moral weakness and a mechanical instrument.

4. A term is either *singular or general or collective.*

A singular or individual term is one which refers to only one thing or individual. It may be a *proper name or a significant singular.* A proper name is a singular term which is applied to a particular person, place or object.

e.g., Krishna, Madras, The Himalayas, etc.

A significant singular term is one which is applied to only one individual object by referring to its significance. It is a uniquely descriptive term.

e. g., The longest river in the world, the present Prime Minister of India, The tallest boy in the class, our college playground, the present leader of the opposition in the parliament etc.

While a proper name is just a sign to indicate a thing, is just an unmeaning mark, the significant singular term is a meaningful reference to one thing which possesses a unique quality or set of qualities.

A general term is one which refers to several similar objects or individuals distributively.

e. g., Students, soldier, tree, etc.

The term 'student' may be applied to any student.

A collective term is one which refers to several similar objects or individuals taken together as a group.

e. g., Library, forest, army, navy, crew, herd, etc.

We cannot point to a single book and call it a library. A library is a collection of books.

Though we have classified terms as singular, general or collective, there are certain exceptions.

A singular term may be used in a general sense. For example, Gandhiji, Harischandra, etc. These terms are applied to several individuals who possess certain characteristics which are originally found in those persons bearing these names.

A term may be viewed as collective from one point of view and general from another. The term 'regiment', for example, is collective with reference to the soldiers who compose it and general with reference to other similar units in the army.

A term may be viewed as collective from one point of view and singular from another. 'The six hundred' is a collective term from one stand point and singular from another.

5. A term is either *abstract or concrete.*

A concrete term refers to a thing which we can perceive with one or more of our sense organs. An abstract term refers to a quality or attribute which we cannot perceive but only understand by the use of the intellect, justice, equality, brotherhood, goodness, patience. These are abstract terms.

Vivekananda College, Rama, Himalayas, tree—these are concrete terms.

6. A term is either *positive* or *negative or privative.* A positive term stands for the presence of an object or attribute while a negative term refers to the absence of an object or attribute.

e. g., Man human, happy, pleasure good, beautiful are positive terms. Unhappy, dishonest, unclean are negative terms.

Generally speaking negative terms are those which have a negative prefix such as 'in', 'un', 'dis', 'im' and or suffix 'less'. We change the positive terms into negative ones by adding these prefixes and suffixes.

For example,

equality	inequality
possible	impossible
clean	unclean
service	disservice
mature	immature
normal	abnormal
aim	aimless
responsible	irresponsible

But there are terms which are not negative though they may have negative prefixes. Immoral, for example, is not the mere absence of morality, but stands for something more positive. Invaluable does not mean what has no value whatsoever but something whose value cannot be properly estimated. Priceless again means having a very high price.

Similarly there are terms which have a positive look, but which are really negative in meaning. Darkness is the mere absence of light; ignorance is the mere absence of knowledge.

A Privative term should be distinguished from a negative etrm. A privative term indicates the absence of a thing which

is normally expected to be present in an object but which is absent in it due to some accident.

e.g., blind, deaf, dumb lame, orphaned, maimed, etc.

7. A term is either *absolute or relative*. An absolute term is one which by itself gives a complete meaning A relative term is one which has a meaning only when the term is taken in relation to some other term. Book, table, tree, etc., are absolute terms. Teacher, parent, leader, father, brother, debtor, etc., are relative terms. The term 'teacher' has a meaning only if taken in relation to the taught.

8. A term is either *denotative or connotative*. If a term primarily refers to an object or class of objects, it is denotative.

e g., Himalayas, library, pollywood, box, tree.

If a term primarily refers to a quality or a set of qualities, it is connotative.

e.g., Equality, humanity, blackness, beauty, mercy, etc

Hints :

(a) All general terms are abstract and connotative,

(b) All singular and collective terms are concrete and denotative.

(c) All negative and privative terms are relative.

II. DEFINITION

Sec. 1. The predicables
Sec. 2. Summum Genus and Infima Species
Sec. 3. Definition (Traditional)

1. The Predicables

In a categorical proposition the predicate attributes certain characteristics to the subject. Different predicates are related to the subject in different ways. These are called predicables. Thus predicables may be defined as the different kinds of relation which predicates can bear to the subject.

Aristotle classified predicables into Definition, proprium, Accidens, Genus and Differentia. Porphyry revised the list. His list consists of Genus, Species, Differentia, Proprium (or Property) and Accidens (or Accident).

Genus and Species: Genus is the class of wider denotation in relation to Species which is the class of narrower denotation, Thus 'Animal' is the genus of 'Man', because its denotation is wider than the denotation of man.

Both Genus and Species are classes and not individuals. In the example, "Ram is a man", the predicate is the Species of the subject and not the genus. In such cases the relation of the predicate to the subject is that of Species to Individual. Similarly, "That fruit is a mango", is an example in which the relation of the predicate to the subject is that of Species to Individual.

Genus and Species are relative. The same term may be genus in relation to one term and species in relation to

another term. 'Animal' is the genus of 'Man', but it is the species of 'living being'. Species which belong to the same genus are called *cognate species or co-ordinate species*. The next higher class of a species is called its *proximum or proximate genus*.

Differentia: It is an attribute or a group of attributes which distinguishes one species from other species belonging to the same genus. 'Rationality' is the differentia of 'man' as it distinguishes man from other animals.

Differentia is a part of the connotation (definition) of a term.

Proprium (or Property): It is an attribute which necessarily follows from the connotation (definition) of a term. (It is not a part of connotation.) 'Mortality' and 'the ability to judge' are properties of 'man'. The former follows from the genus of man, viz., animal; therefore, it is called *Generic property*. The latter follows from the differentia of man, viz, rationality; therefore it is called *specific property*.

Accidens (or Accident): is an attribute which is neither a part of the connotation of a term, nor does it follow from its connotation. These are attributes which make no difference to the essential nature of the term; e. g., 'Man has two legs', 'Pens are usually black', 'Ram was born in Calcutta'.

There are four kinds of Accidents. These are:

(i) *Inseparable Accident of a Class*: These are accidents of the whole class; *e. g.* 'Crows are black'. Blackness is an attribute of all crows, but it is not a part of their cannotation and it does not follow from that connotation.

(ii) *Separable Accident of a Class:* These are attributes possessed by some members of the class; *e. g.*, Students are clever'.

(iii) *Inseparable Accident of an Individual:* These are attributes which are always possessed by an individual; *e. g.*, Socrates was Plato's master', 'Tagore wrote Gitanjali'.

(iv) *Separable Accident of an Individual:* These are attributes which are possessed by an individual sometimes only,

e. g., wearing pants.

2. Summum Genus and Infima Species

The distinction between genus and species is not absolute. What is a genus to one class may be a species to another class and vice versa. For example 'birds' is a genus consisiting of many species like crows, cranes, pigeons, etc. But 'birds' is itself a species under the genus 'animals'. Similarly the term 'animal' is a species, under the genus 'living beings' and 'living beings' is a species under the genus 'Being'. It is not possible to go higher than 'Being' and this highest class is known as *Summum Genus. The Summum Genus cannot be a species.*

Similarly it is possible to split up each one of the genera mentioned above into smaller species. This process comes to a stop when we reach the lowest species beyond which there are no smaller classes. This lower limit is called the *infima species. The infima species cannot be a genus.*

3. Definition (Traditional)

To define a term is to fix its meaning, that is, to make definite the connotation of the term. To define a term is to state its limits. Cannotation gives the limits. Therefore definition is the statement of the connotation of the term.

The formula of definition according to traditional logic is *Per Genus et Differentia.* The term defined is always the species. The formula states that the species should be defined by pointing out the next higher class (genus) and the differentia.

THE RULES OF LOGICAL DEFINITION

Rule 1. *A definition should state the essential attribute or differentia of the species defined.* It is no use stating the proprium or accidens. For e. g., to define 'man' as 'a progressive animal' or as 'an animal which walks on two legs' is wrong. On

the other hand to define man as a rational animal is correct. In short, the definition should be *per genus et differentia.*

Rule 2. *A definition should not contain the term to be defined or any other term that is directly synonymous with it.* The violation of this rule leads to the *fallacy of circulus in definiendo or circle in definition.* Examples of the fallacy : (1) Justice is the way of acting justly. (2) Man is a human being.

Rule 3. *A definition should be neither too wide nor too narrow but strictly equivalent with the species defined.* (1) Tin is a metal lighter than gold. This is too wide a definition, because tin is not the only metal which is lighter than gold. (2) A pump is a water-raising machine worked by a handle. This is too narrow a definition, because there are pumps which are not worked by hand and moreover there are pumps which raise or force things other than water. In short, the definition must be adequate i. e., commensurate; it must fit like a glove.

Rule 4. *A definition should not be stated in figurative or obscure language.* The fallacy arising from the violation of this rule is known as *ignotum per ignotius.* Examples : (1) Bread is the staff of life. (2) Architecture is frozen music. These two are figurative.

If the language is obscure or ambiguous the fallacy is called *obscurum per obscurens.* This is a special from of ignotum per ignotius. Here the words used in defining are less familiar than the term defined. Examples : (1) A net is a reticulated texture with large meshes and interstices. (2) Fluency is exuberance of verbosity. In short a definition should always be simple.

Rule 5. *A definition should, as far as possible, be in positive and not in negative terms.* This is not a very strict rule, because in certain cases a negative definition alone is possible. For example, bachelor is one who is not a married man. Darkness is the absence of light. The fallacy arises only when we give a negative definition where it is possible to give a positive definition. For example, Sleeping is the opposite of waking. Peace is the absence of war,

LIMITS OF TRADITIONAL DEFINITION

Definition *per genus et differentia* is not possible in the following cases.

1. The summum genus cannot be defined, because it has no connotation in the accepted sense. It can only be described.

2. Terms like 'time', 'space', 'centre of the earth' etc., have neither genus nor differentia. They are *sui generis* (unique). Hence they cannot be defined *per genus et differentia.*

TYPES OF DEFINITION

(a) *Systematic definition :* Definition in terms of *genus* and *differentia* assumes that the various things of the world belong to separate and independent classes. But modern science has revealed that things are closely interconnected. The world is a system in which everything is related to everything else. Hence the proper way of defining anything is to point out its place in the system. This is what is known as systematic definition. There are no limits to this kind of definition.

(b) *Genetic definition :* This is a special type of systematic definition. This consists in tracing a thing to its origin (genesis) or describing how a thing comes into existence. In some cases it is more useful to employ this kind of definition than definition *per genus et differentia*. For example, instead of defining water as a liquid which comes down from the heavens in the shape of rain, it would be more satisfactory to define it as the product of two atoms of hydrogen and one atom of oxygen.

III. DIVISION

Sec. 1. What is logical division?
Sec. 2. Division by dichotomy
Sec. 3. Extra-logical divisions
Sec. 4. Division and classification
Sec. 5. The relation between definition and division

1. What Is Logical Division?

Logical division is the process of dividing a genus into its species. It makes clear the denotative significance of a term. The purpose of division is for the sake of making a good definition. Logical division is the process of breaking down a genus or a class or a concept into its logically constituent species.

RULES OF LOGICAL DIVISION

Rule 1. *Division must be based on a fundamental characteristic and not on any superficial feature.* The proper division of man, for example, is on the basis of race, religion, sex or language and not on the basis of their dress or their way of eating. The fundamental characteristics on the basis of which division proceeds is called the principle of division or *fundamentum divisionis.*

Rule 2. *Division must follow the same principle or fundamentum division is throughout.* If somewhere in the middle a new principle is suddenly introduced, we commit *the fallacy of cross division.* If we divide books into scientific, philosophic, cloth-bound and paper bound, we are going on two principles, viz. subject matter and get up, and consequently the fallacy of cross division arises. Other examples of cross division:

Men into white, tall and intelligent.

Students into Hindus, Christians, boys and girls. In short, there must be only one principle of division.

Rule 3. *The species into which genus is divided should not overlap.* They must be mutually exclusive. Neglect of this rule would result in *the fullcy of overlapping division.* To divide Indians into Bengalis, Hindus and Muslims is wrong according to this rule. In short, division must be distinct. There must be no overlapping or blurred outlines.

Rule 4. *The species into which the genus is divided should be collectively exhaustive.* That is, all the species added together must be equal to the genus. Failure to observe this rule results in *the fallacy of incomplete division.* Examples of violation :

Colour into red, green and yellow.
Birds into crows, doves and parrots.
Material bodies into solids and liquids.

In short, division must be adequate. The parts must together be equal to the whole. That is no part must be overlooked.

Rule 5. *Where more than one step is involved the division must proceed step by step so that nothing in the middle may be omitted.* Vertibrates into mammals, birds, amphibians, fishes and snakes. Here one step, viz. reptiles is omitted.

2. Division by Dichotomy

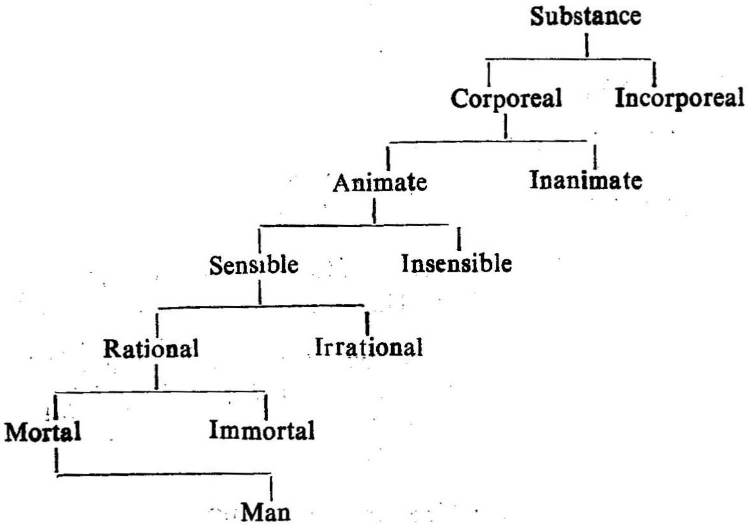
This is a special type of logical division. To dichotomise means to cut into two. In division by dichotomy, we split up a genus into just two species, one positive and the other its corresponding negative.

Examples

Colour into red and not-red.
Indians into Hindus and non-Hindus.
Books into scientific and non-scientific.

The positive and negative species are contradictories to each other. The principle underlying this method is the Law of Excluded Middle, which asserts that between logical contradictories, there is no middle ground. To divide men into saints and sinners or into tall and short are not examples of division by dichotomy because a middle ground is possible in these cases. The popular song which runs, "Accentuate the positive, eliminate the negative, don't fool with Mr. In-between," is a perfect illustration of dichotomous division. The method of dichotomy was illustrated by porphyry, the third century A. D. Logician, in his 'Tree of Porphyry,' which follows.

The Tree of Porphyry



3. Extra-logical Division

Logical division must be distinguished from three other processes. These are :

1. *Verbal division :* This consists in stating the different meanings of an equivocal term, *e. g.* 'vice' into moral evil or a mechanical instrument.

2. *Physical division:* This consists in referring to the various parts which make up a compound substance.

Examples

A chair into the back, the seat, the arms and the legs.

Tamilnadu into districts like Chingleput, S. Arcot, Tiruchy, Thanjavur, Salem.

3. *Metaphysical division:* This is a mental analysis of the different attributes of a thing.

Examples

Milk into fluidity, sweetness, whiteness etc. Metaphysical division is also called conceptual division because it can be accomplished only in thought.

4. Division and Classification

Natural science has given us a process called classification. It consists in arranging a mass of facts into some kind of order. For instance, when the zoologist finds that certain animals resemble in fundamental respects, he groups them together into a species. Many species are further grouped together on the basis of their common features and called a genus. In this manner the process of classification begins from smaller classes and proceeds by combining them into bigger classes. Logical division is closely related to classification. Division begins from bigger classes and proceeds by splitting them into smaller classes. If division is regarded as a downward process, classification is the corresponding upward process. Ideally one is the inverse of the other. Both definition and division aim at precision and clearness.

5. The Relation between Definition and Division

Definition and division are related in two ways, in their structure and in their function.

Structural relationship: In defining a term we state its genus and differentia. The differentia is intended to distinguish the species which we are defining from the genus to which it belongs and also from the other species coming under the same genus. There arises a curiosity in us to know what the other species are. This curiosity is fulfilled in division which gives us all the species of the genus.

Functional relationship: There are two aspects in the meaning of every term namely, denotation and connotation. The meaning of a term can be fully understood only if we make clear both these aspects. Definition makes clear the connotation of a term and division makes clear its denotation. Hence definition and division are complementaries. The work of the one is incomplete without the work of the other.

IV. WHAT IS INDUCTION?

Sec. 1. The two logics
Sec. 2. The problem of induction stated
Sec. 3. The suggested solutions
Sec. 4. Mill's view of inductive generalization

1. The Two Logics

Logic is generally divided into two parts-deduction and induction. In deduction we make use of a universal proposition. For example, in a syllogism we apply a general principle to a particular instance.

All men are mortal beings.
Rama is a man.
∴ *Rama is a mortal being.*

In deduction we merely accept such universal propositions as 'Water boils at 100°C at sea level', 'All material bodies gravitate' as true. We do not inquire how they are derived or wherefrom we get them. But in induction we study the methods of thinking by which we infer a general proposition. Further, in deduction we are interested in the formal validity of an argument. In it we do not inquire whether the argument is true or false, that is, whether it agrees with the actual facts of experience or not. Deduction is the process of formal proof. In it the truth of the propositions composing the argument is not particularly in the foreground. The propositions, in deduction, are regarded as being purely formal. Validity is the chief aim of deduction. For example, the following inferences, according to deduction, are valid.

Examples

(i) All men are angels. Therefore, no men are non-angels.

Though this inference is not true, it is correct or valid because no rule of obversion is violated here.

(ii) All men are those who have wings.
Raju is a man.
∴ *Raju is one who has wings.*

This argument also, though not true, is deductively valid for it does not violate any rule of the categorical syllogism. That is, being valid deductively is different from being materially true (i.e., true to reality). Validity is linked with the form of inference, while truth with the matter of inference. Formal validity of an argument consists in the correct arrangement or sequence of statements ; the material truth of an argument consists in the premises being true statements of facts We are not satisfied with mere formal validity. We want to know whether an argument is materially true or not. Here again we turn to *induction* which *is another word for experience, which guarantees to the truth of an argument.*

2 The Problem of Induction Stated

An argument should not only be valid but also true. The following argument is both valid and true.

All men are mortal beings.
Rama is a man.
∴ *Rama is a mortal being.*

The above argument is true because the major premise 'All men are mortal beings' is true. Now a question arises. How do we know that the major premise is a true proposition ? And where from do we get it ? Some say that the proposition 'All men are mortal beings' is true because it is derived from a previous (pro) syllogism.

Examples

All animals are mortal beings.
All men are animals.
∴ *All men are mortal beings.*

But here again the same question arises: where from and how do we get the new major premise, 'All animals are mortal beings' and how do we know that it is true? There is no use in saying that this again is de-raised from yet another pro-syllogism. For, this way of answering our question leads to an endless series of pro-syllogisms. Hence there is no real solution by this method of going backward and regress. This way of answering is a postponement and not a solution of the problem.

Many say that we derive universal laws from experience i.e. observation of particular instances. Experience is the final source of our knowledge of general propositions. Now a question arises: How do we get the universal proposition (All men are mortal beings) from experience? Our experience is very very limited. We have observed only a few cases of death. On the basis of these cases we say that all men will die. Here we actually make a leap or jump from a few cases which are given to us in our experience, to all cases which go beyond our evidence (experience). This jump is what is called the inductive leap or venture or hazard—i.e., the jump from the known to the unknown, from a few cases to all cases, from the given to the not-given, from the limited to the unlimited, from the observed to the unobserved, from the part to the whole, from the sample to the whole species, from the isolated to the general, from the individual to the whole, from I to A.

How do we derive a general law or principle from a few observed particulars? Or, on what basis do we make a jump from the sample to the whole species? What is the logical basis for the ascent from the particular to the universal? When we have actually observed only a few instances what right have we to generalize about all such instances? In deduction we have seen that we have no right to go beyond the evidence. But in induction we go beyond the evidence, i.e., we proceed from 'some' to 'every'. What right have we to go beyond the evidence? This is the problem of induction. The problem of induction arises because there is a 'gap' between the premises and the conclusion, between the observed facts and the predicated future. *The problem of induction is to arrive at a logical basis for universal propositions.*

3. The Suggested Solution

The answer to the problem of induction depends

(i) on the nature of the facts we study; and

(ii) on the method by which we make the generalization.

Certain facts can be subjected to the methods of analysis and the others not. Where analysis is not possible, we reach the general proposition through the method of enumeration or counting. Thus analysis and enumeration are the main gateways of induction. But the method of counting does not really solve the problem. In counting we do not really go beyond the instances counted. Enumeration is a convenient economy of memory ; it provides no knowledge of connections among facts. It cannot give necessary connection but only constant conjuction. Further a single exception would contradict the generalisation as *enumeration consists of unexamined instances.* Then where does the solution lie? In the method of analysis, where analysis is possible even one typical instance can reveal a universal law. For analysis reveals the inner connections between things. It shows that what is true of a thing of a specific nature will also be true of things of similar nature. Example : From the falling of an apple Newton was able to discover the Principle of Gravitation. After analysing the essential features of a thing we understand the nature of that thing. This understanding of a thing by the method of analysis is expressed in the form of a general law, or universal proposition. So, the proposition, ' All men are mortal beings ' is a convenient expression of our understanding of human nature. In short, a general poposition is our grasp of the necessary relation between the part and the whole. This is the logical justification for inference from 'some' to 'all'.

Our understanding reveals to us that what is once true will always be true in fundamental respects. That is, it reveals that Nature is systematic, coherent and intelligible. Induction abstracts the several particulars into a universal because it believes that Nature is a system. *The passage to the universal from the particular is based on the assumption that nature is*

uniform. Induction assumes the existence of connections in nature. Unless Nature is assumed to be uniform, no generalization from experience is possible. Hence all universal propositions are nothing but expressions of our understanding of Nature. In short, *induction is the process of reasoning from some observed cases to a universal conclusion regarding all similar cases, some of which are unobserved.*

4. Mill's View of Inductive Generalization

According to John Stuart Mill, the only proper form of inference is induction and not deduction. He condemns deduction because he thinks that the conclusion in a syllogism is already contained in the major premise.

Example:

All men are mortal beings.
Socrates is a man.
∴ *Socrates is a mortal being.*

According to Mill, the conclusion, 'Socrates is a mortal being' is already contained in the major premise 'All men are mortal beings'. That is, the case of Socrates is included in the case of 'All' men. Hence syllogistic reasoning is a farce or show because what has to be proved is already assumed in the universal premise.

This charge of Mill against syllogism (deduction) is based on a wrong view of universals. According to this view all universals are aggregates of particulars. 'All' implies 'each and every.' The universals, on this view, is reached through an examination of several particular cases. Mill subscribes to this view when he says that 'All inference is from particulars to particulars'. He gives a concrete example in support of this. 'It is not only the village matron who, when called to a consultation on her neighbour's child pronounces on the evil and remedy on the recollection and authority of what she accounts for the similar case of her Lucy.' Mill says that the village matron proceeds from the particular case of her Lucy to the particular case of her neighbour's child.

But Mill is wrong. The village matron proceeds from the case of her Lucy to the case of her neighbour's child, because she is able to see the common (universal) symptoms of the disease. Because she perceives the common symptoms she is able to suggest a remedy. The village matron's reasoning is based on the understanding of the common element that lies through the particulars. Suppose she found no common element between these particulars (her Lucy and her neighbour's child) it would not be possible for her to suggest the remedy. If two particulars literally stand out as particulars and have no common element, then they can never lead to a conclusion. It is wrong to say that all inference is from particulars to particulars. Hence *all inference lies through a universal.*

V. THE FORMAL GROUNDS OR THE POSTULATES OF INDUCTION

Sec. 1. What is a Postulate?
Sec. 2. The logical basis of Induction
Sec. 3. The Law of Unity of Nature
Sec. 4. The Law of Universal Causation
Sec. 5. The Law of Uniformity of Nature
Sec. 6. Can the postulate be proved?

1. What Is a Postulate?

A postulate is an idea which is assumed to be true. *It is the ground of rational belief*. In every department of life the truth of certain ideas is taken for granted. They are called the fundamental ideas. In mathematics we have the general axioms which make mathematical thinking possible. In religion the existence of God is taken for granted. In the physical sciences we assume the existence of matter. In politics we presuppose the existence of a state. So also logic assumes that there is order in nature. *That nature is a system is the postulate of induction.* It is the assumption of scientific explanation or inquiry. Scientific explanation seeks to discover order in nature. To seek, to discover order is to assume that there is order in nature. Thus science postulates order or system in nature.

2. The Logical Basis of Induction

The logical basis of inductive inference is that natnre is a system, that there are discoverable uniformities in nature. Our experience of the world is in the form of particular facts and events. At first they appear separate, isolated and unconnected. We find no order in them. We are unable to relate events with

one another. Gradually the development of our thinking powers helps us to see order in nature, to connect events with one another, to understand the interrelations and inter-dependence of the events of the world. The function of thought is to discover these inter-connections among the events in nature. Thought does not introduce such connections in nature but recognises or discovers these connections which already exist in nature. *To think is to discover connections or unity among facts*. Nature has many parts which are organically related to one another. There is order in nature. Hence nature is called a cosmos or a system. That, nature is a system, is a fact. This has to be taken for granted to understand nature.

The assumption of logic is that nature is a system of inter-related parts. This fundamental idea is expressed as three laws of nature. They are,

(i) The Law or Principle of Unity of Nature.

(ii) The Law or Principle of Universal Causation.

(iii) The Law or Principle of Uniformity of Nature.

3. The Law of Unity of Nature

This law states the principle that nature is a whole having many parts. These parts are connected with one another. Hence no part is independent of the other parts. If the parts or things in nature had been independent of one another then there would be no order in nature. Then there would no unity or connection in our experience and hence no knowledge. But the fact that different individuals possess common experience and knowledge shows that nature is an inter-connected whole or unity. Nature is a cosmos and not a chaos. It is a universe and not a multiverse. In nature things and events are inter-dependant and not independent. As Creighton puts it, 'Things are not only together but belong together.' Thus we hold the principle that nature is a unity, that it is a system, an organic one, a coherent whole, in which the different parts are closely related to one another.

4. The Law of Universal Causation

The law explains the nature of the relation that exists between things in the universe. Things in the universe are related as causes and effects. Everything in nature has a cause. There can be no event without a cause. Out of nothing, nothing comes. There is no uncaused event in this world. That is, no event in the world occurs by itself. *The Law of Unity of Nature says that things are related.* But *the Law of Causation expresses how they are related.*

5. The Law of Uniformity of Nature

If two things are related as cause and effect, then, if the cause is present the effect must also be present; if the cause is not there, the effect should not occur. This means that there is uniformity in causal connection. That is, *nature is uniform in its causality.* The Law of Causation, properly understood, involves the Principle of Uniformity. Uniformity says, that the connection between cause and effect should always hold good to be called Causation. Thus *the Law of Uniformity makes clear what is already implied in the Law of Causation.* According to the Principle of Uniformity, the same cause will produce the same effect under similar circumstances. Nature always behaves uniformly. In short, uniformity expresses the universality and the necessity of causality. For example, we assume that fire which burns now will always burn hereafter also. That is, the behaviour of things is not erratic, but self-consistent. Hence it is easy to predict the future. Thus we pass from what is known to the unkown.

Uniformity does not mean absence of variety. It means intelligibility. It refers to the 'Regime of Law'. It is rather a wider principle than that of universal causation. Hence *the Law of Uniformity of Nature is the central postulate of all thinking. Mill called this principle as the ultimate major premise in all Inductions.*

All these postulates express the same truth that nature is a system in three different ways. Unity expresses that things

are connected. Causation expresses that things are connected. And uniformity expresses that the causal connection is consistent. Thus induction assumes that nature is a coherent, causally connected, consistent cosmos. As these three principles form the basis of Induction, they are called the formal grounds of Induction.

6. Can the Postulate be Proved ?

A postulate is the very root and foundation of any field of knowledge. As the postulates are the formal grounds of our experience, they cannot be proved by experience. To deny them is to deny the possibility of reasoning altogether. The Postulate of Induction cannot be proved because :

(i) It is not a derivative principle from experience. On the other hand, it is the constitutive principle of experience.

(ii) An attempt to prove it will involve the very idea to be proved.

(iii) Further, the contrary of the postulate is unthinkable. This itself is proof positive to show that the postulate is validated.

VI. STAGES IN THE INDUCTIVE METHOD OR THE METHOD OF SCIENTIFIC INQUIRY

Sec. 1. Description.
Sec 2. Explanation.

1. Description

Inductive process is the correct way of thinking by which the scientist discovers universal laws from particular facts learned through experience. Description and explanation are its two stages. That is, in Induction, our mind passes from the observation of sufficient number of instances to a general principle that connects and explains them.

Whenever we have a problem, we want to solve it. To solve a problem, we have to collect relevant facts about that problem. That is, we must understand all the aspects of the problem. This is what is called 'Description or Collection of Facts'. Since description consists in observing all the relevant facts, it is sometimes called 'Observation'.

2. Explanation

Facts collected must be connected, To connect facts is to explain them by means of an idea. Explanation is a form of interpretation or understanding of the collected facts. It is a search for a general rule or idea underlying the facts. This search for a general idea occurs in the form of a tentative suggestion. This provisional suggestion is called a hypothesis. Thus *a Hypothesis is a suggestion of connection.* This suggestion may be true or false. A hypothesis is true if it agrees with the

facts of the problem. It is false if it does not agree with the facts. So, we have to verify the hypothesis to see whether it is true or false. That is, we have to compare the hypothesis with the actual facts. To verify the hypothesis we have again to observe facts. If the hypothesis does not agree with the facts, then it is rejected.

A rejected hypothesis is not useless. It points to some aspects of the problem which has not been observed previously. It directs our search for further facts to enable us to suggest a better hypothesis. After a hypothesis is rejected, the problem is re-examined, fresh facts are collected and a new hypothesis is framed and tested as before. Thus the process of framing and testing the hypothesis alternates with the description of facts. This process goes on till we get a hypothesis which will satisfactorily explain the problem.

When a hypothesis is found true, we must prove that the hypothesis is the only hypothesis that will explain the facts. This is called the proof of hypothesis. Proof consists in showing that the problem cannot be explained by any other hypothesis. The formation of hypothesis, the verification of hypothesis and the proof of it are the three steps of explanation.

When a hypothesis explains all the problems of similar nature, it is expressed in the form of a law. A well established law is called a fact. Thus real explanation consists in observing and understanding all the relevant facts of a problem. The work of collecting facts and the work of explaining them proceed side by side, acting and reacting on each other. Observations (Description) supplies us the data for inductive generalization. Without it scientific investigation cannot begin. And without observation it cannot be sustatined. *Observation constitutes the beginning, it supports the middle and determines the end of every induciive inquiry.* Thus, observation becomes a permanent factor in inductive inquiry. Without description, a problem cannot arise, a hypothesis cannot be framed, an inference cannot be confirmed. Hence it is said that the differenee between description (observation) and explanation is

only relative and not absolute. They differ only in degree and not in kind. Explanation begins concurrently with observation. The only difference between them is that *explanation implies a greater degree of analysis than description.* The distinction between description and explanation can be made clear by the following example. Kepler observed the different positions of the planet Mars and found that it moved in an elliptical orbit. This is observation or description of facts. Why it moved in an elliptical orbit was explained by Newton when he related it to the principle of gravitation. Thus observation and explanation involve each other. The hypothesis determines the observation and observation in turn helps to frame a hypothesis. Hence *explanation is only fuller or precise of complete description.* Thus science is only a refinement and extension of common sense.

To sum up: The inductive process or the scientific method of inquiry consists of the following steps:

(A) *Description :*

(i) Observation or collection of facts.

(B) *Explanation :*

(ii) Formation or suggestion of hypothesis.
(iii) Verification or testing of hypothesis.
(iv) Proof or establishment of hypothesis.

VII. OBSERVATION AND EXPERIMENT

Sec. 1. The material grounds of Induction.
Sec. 2. What is observation ?
Sec. 3. What is experiment ?
Sec. 4. Advantages of Experiment.
Sec. 5. Advantages of Observation.
Sec. 6. Aided Observation.
Sec. 7. Natural Experiment.
Sec. 8. Fallacies incidental to observation.

1. The Material Grounds of Induction

The first step in induction is to collect facts. This is called description. Observation and experiment are the two methods of description. They help us to collect facts or materials connected with the problem. The observed instances constitute the data of inductive inference. Hence observation and experiment are called the material grounds of induction.

2. What Is Observation ?

Observation is the process of collecting the relevant facts of a problem as they are. It consists in observing events and changes juat as they occur in the course of nature without our attempting to control or produce them by artificial means. Thus, when we study the habits of ants in our gardens, we are using the method of observation.

The facts and problems studied by observation are always complex by nature. To understand the problem clearly, we must isolate the essential conditions from the unessential. That

is, we have to analyse the facts or problems to understand and describe their true nature. Since observation involves analysis, it is an active process. Again, one's observation is determined by the purpose one has in his mind, That is he has an idea as to what facts should be observed in order to solve the problem. He does not proceed to collect facts in an aimless manner. On the other hand he selects the facts. Thus observation is an analytical, active, purposive and selective process. It is regulated perception.

3. What Is Experiment?

When fatcs are observed under natural conditions, it is called observation. But facts can also be observed after introducing certain conditions not present in nature. This is called experiment. Experiment is nothing but controlled observation. In it the situation is under the complete control of the observer. In simple observation the facts observed are due to nature, In experiment they are arranged by ourselves. The essence of experiment lies in varying the circumstances. As Bacon says, in experiment we can put definite question to nature and compel her to answer. Observation is finding a fact while experiment is making one. Observation becomes experiment if observation under conditions is pre-arranged and controlled by the observer. Thus experiment is not opposed to observation. It is only a special type of observation. Experiment is observation with a trained eye, it is a deliberate observation of expected results. Experiment is done for better, fuller and more accurate observation.

4. Advantages of Experiment

The method of experiment is highly valuable. It has certain advantages over observation. They are :

(i) In experiment the situation is completely and thoroughly under the control of the scientist. He is at liberty to introduce changes as he likes, withdraw any condition which may spoil the experiment, or modify the entire experiment if

necessary. But in observation the situation is not under the control of the scientist. Here he is completely depending on nature to gather facts. So he can neither introduce changes in the phenomenon nor can he modify it. He must either observe what is given to him or leave It.

(ii) An experiment can be repeated several times by the scientist before he gets a satisfactoy result. But in observation the situation is produced by nature. A thunder storm is produced by nature. We cannot have it whenever we want to have it. Hence to study certain situations in nature we have to wait patiently—sometimes for many years for the situation to occur. In short, in observation we are completely at the mercy of nature.

(iii) It is possible, in experiment, to isolate the essential facts from those which are not essential. This helps us to acquire precise knowledge of a phenomenon in which we are interested. For example, in an experiment, the scientist can analyse air, isolate oxygen and fihd that it supports burning. But in observation it is very diffcult to secure such a precise knowledge because in nature the facts are given to us in a very complex form—the essential and the non-essential elements being present at the same time.

(iv) Further the same experiment can be conducted under different conditions of the phenomenon. To study, for example, the effects of a particular medicine, it can be prescribed to patients belonging to different age groups, living under different conditions and in different climates. Needless to mention this is not possible in observation.

(v) The essence of experiment lies in varying the circumstances. In an experiment the scientist can vary or modify the conditions and study how the phenemenon behaves. Thus by experiment we ascertain that a substance called nitric acid dissolves various kinds of metals such as iron, copper, silver but cannot dissolve gold. Besides in experiment causal connections can be established. For example, we can vary the

amount of air in a bell-jar, and by ringing the bell each time we can show that a medium like air is necessary for the transmission of sound. Such things are not possible in observation.

(vi) Exact quantitative determination of cause is possible in experiment. For example, simple observation may tell us that water boils when heated but it is experiment that tells us how much of heat is necessary for water to boil.

(vii) In experiment it is possible to observe the phenomenon calmly, leisurely and without any anxiety. For the entire field of experiment is under our control. But in observation the phenomenon may take place all of a sudden at a time when we do not expect it at all. Hence we may become excited. Our observation of such phenomenon will be very hasty and careless.

(viii) But for the method of experiment, the sciences like chemistry, physics would not have been developed as rapidly as they have been in recent years. On the other hand, sciences like economics, politics, sociology, etc., which entirely depend on observation, have made only a very slow progress. Their conclusions are not as clear and certain as the conclusions of those sciences which have the method of experiment at their command.

5. Advantages of Observation

The method of observation in its turn has certain advantages over experiment. They are :-

(i) It is not possible to conduct experiment everywhere. Where experiment is out of question, observation alone will be our method to obtain facts. For example, to study the nature of thunderstorm, comet, the sun, the moon, earthquake, etc., or to study the development of society, the consequences of war or famine or riot or strike, the

working of a particular type of government etc., observation is the only method which will be of immense use to us.

(ii) Again, observation prepares the ground for experiment. To conduct an experiment one must have observed the fact previously and acquire some knowledge about them. On the basis of this knowledge only, can the scientist determine the nature and scope of the experiment that he wants to conduct.

From all these we should never imagine that experiment is opposed to observation. To gather facts about a phenomenon both are necessary and useful. What method should we use in a given situation depends largely on the essential nature of the situation that we want to investigate. Sometimes experiment will be of great help to us, sometimes observation, sometimes both. Both observation and experiment are interdependent. They help each other.

6. Aided Observation

Sometimes we make use of instruments in obseivation. Observation with the help of instruments like the microscope, telescope, thermometer, balance, stethoscope, etc., will be more clear and accurate than without them. This is what is called aided or instrumental observation. Aided observation should not be confused with experiment. The difference between the two is this. In experiment we are actually introducing certain conditions in the situation ; whereas in aided observation we are not modifying the conditions, but observing the phenomenon through special instruments. The use of these instruments does not at all affect the phenomenon observed. For example, by using the clinical thermometer we are only observing accurately the temperature of the patient. The mere use of the thermometer does not bring about any change in the condition of the patient.

7. Natural Experiment

Certain aspects of nature are always beyond our control. But still we can choose favourable conditions for observation of such aspects. These favourable conditions are created by nature itself. That is, nature itself, under special circumstances, arranges or modifies the facts for our observation. This type of observation is called natural experiment. Example: Under the solar or lunar eclipse, we find a set of unusual conditions produced by nature for our observation. Strictly speaking, natural experiment is only observation of a special type. For, the observer is not introducing any change or condition in the phenomenon. It is called 'natural experiment' because it seems as if nature herself is conducting an experiment for us.

8. Fallacies Incidental to Observation

Scientific observation is the impartial and unprejudiced collection of facts. It should be objective. The aim of observation is to see a fact as a fact. This requires that the observer should fulfil certain conditions. While observing facts to solve a problem, the observer must be free from his pet ideas, superstitions and personal prejudices. He must be firmly detached and absolutely disinterested. He must not observe facts with preconceived notions. He must keep an open mind. He must be prepared to reject his hypothesis if the observed facts go against it. Facts should not be twisted to suit one's whims and fancies. The scientist's work is *for* his purposes, but not *of* his purposes. The scientist must be aware of the danger of allowing his own prejudices to distort his findings. The habit of forming a judgement upon facts as facts, unbiased by personal feeling is the characteristic feature of the scientific frame of mind. In short, the observer must have intellectual integrity, sincerity of purpose and an urge to discover the truth at any cost. It is well expressed in Huxley's exhortation to scientists to "sit down before the facts as a little child, and let them lead you where they will".

If these conditions are not fulfilled, observation becomes subjective and hence fallacious. The resulting fallacies are :

(i) *The fallacy of non-observation:* This consists in not observing certain relevant facts of the problem which should have been observed. The observer either deliberately or accidentally omits certain conditions which should not have been omitted. Non-observation is a fallacy of omission. It is a negative fallacy. This fallacy arises either because we neglect to observe an adequate number of instances of a phenomenon or because we neglect to take note of some of the details in the instances we observe. Bacon calls this fallacy " the Idols of the tribe " as non-observation is a common weakness of the whole tribe of men. " Men mark when they hit and not when they miss ". All popular superstitions are good examples of this fallacy. Thirteen is an unlucky number, works started on Tuesdays are bound to fail.

(ii) *The fallacy of Mal-observation :* This consists in mis-interpreting the fact observed. The observer sees the facts, but sees them wrongly. This is a fallacy of commission. Examples :-Mistaking a lamp post for a thief in darkness, mistaking a piece of nacre for a piece of silver, etc. Similarly we observe the various positions of the sun in the sky all through the day, but we say we observe the sun moving.

VIII. HYPOTHESIS

Sec. 1. What is a Hypothesis ?

Sec. 2. Requirements or Conditions of a Good Hypothesis.

Sec. 3. Verification and Proof of a Hypothesis.

Sec. 4. False and Barren Hypothesis.

1. What is a Hypothesis ?

The work of science is not only to collect and describe the facts but also to connect and explain them. Isolated facts are useless for science. Facts must be ordered and connected. But the connections among facts cannot be perceived directly. So, they are put forward as suggestions. These suggestions are called hypotheses. A hypothesis is a suggestion of connection. In other words, a hypothesis is a tentative proposal for the solution of a problem. It organises a group of observed facts under a principle. It is a supposition which has been put forward in order to account for what happens. It is a suggestion which presents a possible cause. It is an idea which is capable of ordering facts. It is a suggested explanation. Thus every hypothesis guides the enquiry and systemetizes the observed facts. A hypothesis must be tested before it is accepted. That is, it is a candidate for verification.

Science attempts at exactness by discovering causal connections among facts. All attempts at discovering causal connections proceed by ways of a hypothesis. A hypothesis then, is a guess about the cause of an event. The formation of hypothesis is the central feature of all inductive inquiry. Hypothesis is involved in every stage of induction. In observation hypothesis plays a part. Unless we have a tentative idea we cannot know what to observe. The observed facts

acquire meaning and significance only when viewed in the light of an idea or hypothesis. The purpose of observation is to find evidence for or against a hypothesis. Hypothesis, in short, is the pivot of induction.

2. Requirements or Conditions of a Good Hypothesis

As a hypothesis ties all the relevant facts into an explanation, it must satisfy certain conditions. They are :

(i) It must be thinkable.

(ii) It must be compatible.

(iii) It must be verifiable.

Let us explain these principles governing the choice of a good hypothesis.

(i) A hypothesis must be thinkable. That is, the suggestion that we make to explain a set of facts must be conceivable and not absurd. This must be a justifiable guess and should not be and unfounded and baseless one.

(ii) A hypothesis must be compatible. That is, it shall not contradict any established fact. It should be in general agreement with facts known. But these two conditions of a hypothesis are not absolute conditions. For what is inconceivable at one period may be conceivable at a later period. At one period in the history of science it was inconceivable that atoms could be split. But now the story is different. Similarly what we believe to be an established piece of knowledge may be modified or rejected at a later period. So we should not reject a hypothesis simply because it lacks harmony with known facts. So we may interpret these two conditions to mean that a hypothesis is not a mere guess but must be based on facts. They warn us that we should not make wild guesses. These two conditions mean that a hypothesis should provide a relevant explanation. That is, a hypothesis must be logically possible and should not involve self-contradiction.

(*iii*) *The hypothesis shall be verifiable.* It must lead to verifiable consequences. It must indicate a line of enquiry. It must be a justifiable assumption. That is, its truth can be tested. It should be capable of deductive development. It should have predictive power. This is the most important condition for it is related to the verification and proof of the hypothesis. In other words 'a guess is worth making only if the answer can be tested'.

3. Verification and Proof of a Hypothesis

Verification is the process of testing a hypothesis or finding out whether it is true or false. Verification consists of two stages : (a) Deduction of consequences and (b) Agreement with facts.

(a) *Deduction of consequences*

First we assume the hypothesis to be true and infer certain consequences which follow from it.

(b) *Agreement with facts*

Next we observe whether the deduced consequences agree with facts. That is, the consequences are compared with actual facts. It they agree then the hypothesis is accepted as true. If they do not agree, the hypothesis is either modified or rejected. Example : Water was found (observed) to rise to a particular height in a pump from which air was removed. To explain the fact Torricelli suggested a hypothesis. His hypothesis was that the pressure of air made the water rise in the pump. Assuming the hypothesis to be true, a consequence was deduced. If the hypothesis is true, mercury which is fourteen times heavier than water should rise only to 1/14th the height of water. An experiment was conducted and mercury was observed to rise to the expected height. Thus. the hypothesis was verified. When a hypothesis has been verified it is called a theory.

The procedure adopted in the verification of a hypothesis is purely deductive. It is as follows :

Major Premise: If this hypothesis is true, x, y, z must be the consequences.

Minor Premise : x, y, z are the consequences.

Conclusion : This hypothesis is true.

This hypothetical syllogism commits the fallacy of affirming the consequent. This fallacy will disappear if we can prove that the given antecedent is the only antecedent or *sine qua non* of the consequent. In other words, we have to demonstrate that the suggested hypothesis is the only hypothesis which will explain the facts. From this it is clear that verification alone is not enough. Verification is different from and incomplete without proof. To prove is to show that no other explanation of the facts is admissible. Verification consists in the confirmation of evidence for the truth of the hypothesis, while proof consists in the conclusive evidence of the truth of the hypothesis.

The proof of a hypothesis consisting in showing that the suggested hypothesis is the only hypothesis that will explain the facts adequately. That is, the hypothesis must claim exclusive connection with the observed facts of which it is a hypothesis. Therefore to prove a hypothesis we have to search for other possible hypothesis and eliminate them by a more complete survey of facts. We have to decide which is the best hypothesis. For this we look for a fact which will help us to decide among rival hypotheses. If such a fact is found in nature, it is called a crucial instance. If the fact is got by experiment, the experiment is called crucial experiment. Thus we find a crucial instance or conduct a crucial experiment to decide betwen rival hypotheses and eliminate the other hypotheses from the best one. Example : In the illustration we have taken already, a rival hypothesis had been suggested to Torricelli's hypothesis. The rival hypothesis was that water arose to particular height in the pump because nature wanted to fill up empty space. The rival hypothesis was that nature

abhored vacuum. Now it had to be decided whether this rival hypothesis or Torricelli's hypothesis was the correct one.

A crucial instance or experiment alone could help us to decide the issue. In this case a crucial experiment was conducted. It was as follows: Two experiments were conducted, one on the plains and the other on the top of a mountain. If the hypothesis that nature abhored vacuum were the correct one, then water should rise to the same height in both the places. But on verification it was found that in the pump on the mountain water rose to only less than the expected height. That is, water was found to rise to different heights in the two places. This could be explained only by Torricelli's hypothesis, namely air pressure; and the pressure of the atmosphere varies with the height of a place. Thus Torricelli's hypothesis was demonstrated to be a better hypothesis.

A hypothesis is said to be proved only if it can explain a large number of facts connected with the problem. That is, it should explain allied facts. This is called consilience of results or consilience of induction. Example: Newton's theory of gravitation explained not only the falling of an apple but also several other allied facts like tides of the sea, the orbit of the planets, the path of the comets etc. Similarly Torricelli's hypothesis explained not only the rising of water in the suction pump to a particular height but also what is popularly known as the Magdeburg hemispheres. When a hypothesis is well established it is called a law. Thus a hypothesis is an unverified suggestion. A hypothesis that is verified is called a theory. Whena theory is proved it is called a law. A well established law is called a fact.

4. False and Barren Hypothesis

A hypothesis which is found to be unsatisfactory when verified is called a false hypothesis. It is a hypothesis which breaks down on verification. It does not agree with or explain

actual facts. Verification reveals that the hypothesis is false. A false hypothesis has to be rejected. But we have already seen (chapter Sec. 2) that a rejected hypothesis is not altogether useless. It is a pointer to a better hypothesis. It directs our attention to unobserved facts which ought to have been observed.

A hypothesis from which no consequences can be deduced is called a barren hypothesis. A barren hypothesis is one which does not suggest the deduction of observable data. It is a hypothesis which cannot be put to test. Example: The child fell ill because a wicked woman's evil eye fell upon it. This is useless hypothesis bacause it cannot be verified.

We should note the distinction between a barren hypothesis and a false hypothesis. A barren hypothesis is incapable of deduction of conseqence, i. e., it does not admit of verification. But a false hypothesis is one that has been verified and found unsatisfactory. A barren hypothesis is one that cannot be verified and therefore illegitimate. A false hypothesis is an erroneous hypothesis, a legitimate but an unsuccessful one. Example :—The hypothesis that nature abhors vacuum, Ptolemy's hypothesis that earth was at the centre, etc.

IX. KINDS OF INDUCTION

Sec. 1. Introduction

Sec. 2. Scientific Induction

Sec. 3. Enumerative Induction

(A) Complete enumeration

(B) Incomplete enumeration

(C) Value of enumerative induction

Sec. 4. Analogy

1. Introduction

Induction is the process of reaching a general proposition on the basis of a few observed particulars. Analysis and enumeration are the two ways which justify this process of passing from "a few" to "all". Induction which uses the method of analysis is called scientific induction, and induction which is based on counting the instances is called enumerative nduction. There is another method in induction which comes very near scientific induction and it is the method of analogy. Though analogy is not an enumerative method it is also an incomplete inductive method because it simply stops with suggesting a hypothesis.

The following table will show the different kinds of induction.

- Induction
  - Scientific
  - Imperfect
    - Enumeration
      - Complete
      - Incomplete
    - Analogy

Let us discuss these different kinds of induction one by one.

2. Scientific Induction

This is induction by scientific analysis. It involves the processes of description and explanation. By virtue of its employing the method of analysis, scientific induction acquires certain characteristics. The characteristics of scientific induction are :

(i) Scientific induction is not based on the mere number of instances. The scientist collects facts for their nature or quality or type and not for the number. He selects typical instances, i. e., instances which reveal the different aspects of a phenomenon. Scientific induction is not interested in similar instances but in significant instances. What justifies the problem of induction is the nature of evidence we have for it and not the number of instances. The nature of evidence depends on (a) the sufficient number of typical instances examined and (b) the careful observation of the absence of contrary instances.

(ii) Scientific induction proceeds by the method of analysis and not by the method of counting. For, analysis reveals inner connections underlying the things. Where analysis

is possible even one typical instance can reveal a universal law. That is, it can reveal the causal connection among the facts observed. Hence a conclusion reached by the method of analysis is certain. It cannot be overthrown by a contrary or negative instance. As an exception such a contrary instance will prove the conclusion rather than overthrow it. An exception proves the rule. But a conclusion reached by the method of counting is only probable and not certain. It can be easily overthrown by a contrary instance.

(iii) Scientific induction implies a leap or venture.

(iv) The general proposition reached by scientific induction states a law of connection. It makes no direct reference to individual facts. Hence Creighton says, " Scientific induction aims at establishing a universal law that does not refer primarily to cases or instances at all ". Example: " Heat expands metals. " This scientific universal refers not to the particular cases of heating and expansion of metals, but states the causal connection between heating and expansion as such. It is merely a statement of a principle and not a reference to the particular instances observed. Hence it becomes necessary in induction to apply such causal statements to particular facts. Though inductive generalizations arise out of an analysis of particular facts, they go beyond the level of the facts. The general proposition reached by scientific induction is called a generic or scientific universal. It is to be distinguished from the collective or numeric universal, which is reached by merely counting the instances observed. Such a universal remains at the level of the facts observed and it is a mere collection. In counting we do not really go beyond the instances. The general proposition reached by the method of counting is merely a summation of observed particulars; it is a mere summing up of the results of unexamined experience. It does not refer to any necessary connection between facts. So it is always at the mercy of a negative instance.

(v) Scientific induction formulates a hypothesis and provides for its verification and proof.

That is scientific induction adopts the following four stages:

(a) Description of facts;

(b) Formation of a hypothesis;

(c) Verification of a hypothesis; and

(d) Proof of a hypothesis.

Thus scientific induction involves two processes—description and explanation.

3. Enumerative Induction

To enumerate means to count. In this method a generalization is reached by the process of counting the instances observed. Enumerative induction is of two kinds.

(A) Complete enumeration.

(B) Incomplete enumeration.

A. Complete Enumeration

It is also called perfect enumeration. Jevons calls this method 'perfect induction'. According to this method we count *all* the instances and then make a generalization. The method is based on exhaustive counting of instances. It is called 'perfect' because when all the instances are observed the conclusion cannot go wrong. Examples: After observing each and every student in a college we say that all the students in that college are those who have passed the S. S. L. C. or Matriculation examinations. Similarly after observing each and every fruit in a basket we say that all the fruits in the basket are mangoes.

Defects of this method

(i) Complete counting is not possible where the number is too large. Generalizations like " all material bodies gravitate ", " all men are mortal " cannot be reached by this method for it is not possible to count all the instances.

(ii) The method is the very negation of scientific induction for the following reasons. (a) The generalization is based on the mere number of instances and not on their nature. (b) It is based on the method of counting and not on the method of analysis. (c) There is no inductive leap. When all the instances are counted there is nothing to infer. (d) The generalization is not a scientific universal but only a collective one. It is not a statement of causal connection. The conclusion is a convenient summary of what we already know. (e) This method does not explain facts, but simply describes the instances observed. Hence it is wrong to call this method "perfect" induction. This method does not deserve the name induction at all.

B. Incomplete Enumeration

It is also called imperfect induction or imperfect enumeration or simple enumeration. In this method we reach a conclusion after counting only *some* instances of the phenomenon. The conclusion is reached by the method of counting a large number of similar instances. Simple enumeration, in other words, is a process of generalization based on uncontradicted experience. Example: I have observed a large number of crows and all of them are black. Hence I conclude that all crows are black.

In this method we proceed from the known to the unknown, from the observed to the unobserved instances. Hence, there is the inductive leap or venture.

Defects of this method

Though this method possesses the inductive leap it is an incomplete form of induction for the following reasons :

(i) The method attaches much importance to the number of instances. It assumes that greater the number of instances counted, the stronger becomes the conclusion. It piles up the same type of instances,

(ii) In this method the instances are merely counted but never analysed. Hence the causal connections among facts are not revealed.

(iii) The conclusion is liable to be overthrown by a negative or contrary instance. It is always at the mercy of a negative instance.

(iv) Hence the conclusion is only a collective universal and not a scientific universal.

(v) The method is descriptive and not explanatory. For example, it shows that crows are black but not why they are black.

(vi) In this method we are likely to commit the fallacy of hasty generalization. This fallacy arises when we generalize on the basis of instances which are neither sufficient nor typical. Exampale : In a certain town three or four persons cheated me. From that I conclude that the people of that town are dishonest.

C. Value of Enumerative Induction

Enumeration is a lower and less complete form of induction. It is the beginning rather than the end of induction. It prepares the ground for scientific induction. It is true that enumeration reveals only constant conjunction and not causal connection. But a constant conjunction may lead to the discovery of causal connection. For example, when we find that a large number of crows are black we begin to think that there must be some connection between the constitution of the crow and its colour. We are provoked to inquire whether there is really a connection and if so what it is. Thus enumeration is helpful in starting the inductive inquiry. Sometimes it is a fruitful source of hypothesis. Though itself not analytical, enumeration provokes analysis. Further it is useful in cases where analysis is not possible, e.g., the statistical method of counting. Inductions from enumeration do not give us *certain* knowledge, but merely degrees of probability.

4. Analogy

A. What is Analogy ?

Analogy means resemblance. It is the process of reasoning from one thing to another on the basis of resemblances between them. Two things resemble each other in some respects. From this we infer that they probably resemble each other in other respects also. Example : The planet Mars resembles the earth in certain respects. They possess similar atmosphere, land, seas and temperature. From these similarities we infer that Mars may also be inhabited like the earth. Reasoning by resemblance is called Analogy. Analogy is a means of explaining the unknown by the better known.

B. Conditions of Valid Analogy

An argument from analogy should satisfy the following conditions.

(i) The points of resemblance must be fundamental, relevant and essential to the conclusion inferred. They should not be superficial and irrelevant. Only significant resemblances have value in analogy. The value of analogy depends not on the mere number but on the nature of the points of resemblance. In other words, in analogy, we weigh the points of resmblance and not merely count them. If this condition is not satisfied, analogy becomes unsound (or bad or false) Example : Two students resemble each other in several respects like height, complexion and dress. They reside in the same place and have their education in the same institution. If one passed in the first class we cannot infer on the basis of these resemblances that the other will also pass in first class. For the points of resemblances mentioned here have nothing to do with passing the examination in the first class. Intelligence and industry alone are essential for success in the examination.

(ii) Important points of difference between the things compared should not be ignored. An analogical reasoning may be based on the essential points of resemblance. But if significant differences are omitted, the analogy will become

unsound. In the example given above both the students may be industrious and intelligent. On this basis alone we should not say that if one passes in the first class the other also must have passed in the first class. Suppose one student has not written the examination due to certain reasons. If we have not noted this important difference, that is, one appearing for the examination and the other not, our analogy, though based on fundamental points of resemblance, is unsound. Hence when we compare two things we have to take into account the important differences between them.

(iii) We must have adequate knowledge of the two things compared. If our knowledge of the two things compared is not fairly exhaustive the analogy will become unsound. If all these conditions are observed carefully, the probabitity of the conclusion is very near certainty. Otherwise the probability is zero. In short, the validity of an analogy depends on the aptness and relevance of the comparison.

C. The Value and the Defect of Analogy

The value of analogy is that it suggests useful hypothesis. It is a fertile source of hypotheses. By suggesting the hypothesis, analogy starts the process of explanation. Thus it enters into the inferential processes of induction. Example: Newton perceived a deep resemblance between the heavenly bodies falling through space and the falling of an apple to the ground. This analogy suggested to him the hypothesis of gravitation. The value of analogy depends on the character, relevance and real connection of the points of resemblance with the inferred resemblance.

The defect of analogy is that it is incomplete. It contains a pinch of uncertainty. It suggests a hypothesis. But it cannot proceed further to verify the hypothesis. Partial resemblance is no proof of total resemblance between things. Analogy yields only probable conclusions. Analogy, in this sense, is probability. That is why Mill says that analogy belongs to the logic of discovery and that it has no place in the logic of proof. It is a mere guide-post. Hence analogy is only a stage in induction.

X. CAUSAL RELATION

Sec. 1. Mill's definition of Cause

Sec. 2. Defect of Mill's definition and a more satisfactory definition of Cause

Sec. 3. The scientific and popular views of Cause

Sec. 4. The Doctrine of Plurality of Causes

Sec. 5. Composition or conjunction of causes and Intermixture of Effects

Sec. 6. Fallacies of Causation

Causal relation is an important concept in Induction. The first postulate of Induction itself is that every event has a Cause.

1. Mill's Definition of Cause

Mill has defined Cause as the "invariable unconditional antecedent of a phenomenon."

He says that the cause of a phenomenon is its antecedent. It means that the cause takes place first and then the effect follows.

But *any and every antecedent cannot be the cause*. Every phenomenon has a large number of antecedents which have simply no connection with the phenomenon. Suppose a crow sits on a tree and immediately after a fruit falls to the ground it is wrong to argue that the 'crow-sitting' is the cause of the 'fruit falling'; The fallacy is known as *post hoc ergo propter hoc* (after this, therefore because of this). An event cannot be regarded

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as the cause of a phenomenon merely because it is its antecedent. It should be the invariable antecedent of the phenomenon, i.e., it must always precede the phenomenon.

Even invariable precedence is not a sufficient sign of cause. Night is the invariable antecedent of day. but it is absurd to say that night is the cause of day. Night always precedes day because the earth rotates. There is no essential connection between night and day. Day merely follows night but does not follow *from* night. Mill says that the invariable antecedent must be unconditional and necessary.

That is, it must not depend on any condition other than itself. Hence cause is "the invariable unconditional antecedent of a phenomenon."

Cause is here described as an antecedent. It appears as though the cause is single circumstance or condition. But really cause is a group of conditions all of which are necessary for the production of the effect. The pressing of the trigger alone is not the cause of the explosion of a gun. It is only one of the conditions. Other conditions like the proper form of the barrel, the quality of the powder, the absence of moisture etc., are also necessary for the powder, the absence of moisture etc., are also necessary for the explosion. Some of these conditions are positive and some are negative. Positive conditions are those which must be present if the effect is to be produced. Negative conditions are those which must be absent if the effect is to be produced. All those conditions, both positive and negative, taken together constitute the cause. Hence Mill says "Cause is the sum-total of the conditions positive and negative taken together." Quite often people mistake a single condition for the whole cause. This is a fallacy.

2. Defect of Mill's Definition and a More Satisfactory Definition of Cause

Mill's definition does not bring out the inner logical relationship between cause and effect. It represents causal

relation as merely temporal and external. Mill simply says that the cause is the antecedent and the effect is the consequent. Cause is before in time and the effect after in time. It seems as though the cause first takes place and stops and then after a pause the effect suddenly occurs. This gives us the impression that there is no connection or continuity between cause and effect. This is wrong. They are continuous. There is no break or separation between them. For example, oxygen and hydrogen do not combine first and *then* produce water. On the other hand, the combination of oxygen and hydrogen is itself water. Thus there is an inner growth or development from cause to effect. So the cause is concealed effect and the effect is the revealed cause. The effect does not simply follow the cause but follows from the cause. The relation between cause and effect is not one of mere time-sequence but of logical necessity. The relation is not external but internal. Hence from the point of view of science, cause is that without which the phenomenon would not occur. This is the most satisfactory definition. Mill's definition does not bring out the inner logical relation between cause and effect. His picture of causal relationship is somewhat artificial. That is why it is said that "Mill's conception of cause as the invarible unconditional antecedent relates to a static universe which is wholly non-existent ".

3. The Scientific and Popular Views of Cause

1. The ordinary man confuses a single condition with the whole cause. But the scientist clearly sees that the cause is a totality of conditions.

2. The ordinary man thinks that one and the same effect may be produced by several different causes (the doctrine of plurality of causes). But science holds that identical causes always produce identical effects. It believes in the Principle of Uniformity of Nature.

3. Science believes that cause and effect are quantitatively equal. For example, when hydrogen and oxygen combine to

form water, the weight of water is equal to the weight of the two gases combined.

4. Science believes that the connection between cause and effect is continuous and not discontinuous. But the ordinary man does not perceive this inner growth or development from cause to effect. He thinks that the cause comes first and the effect afterwards.

4. The Doctrine of Plurality of Causes

The popular mind thinks that one and the same effect may be produced by many separate causes. Death, for example, may be produced by drowning, poisoning, gun-shot, hanging, etc., or heat may be produced by friction, electricity, fire, etc. This is known as the Doctrine of Plurality of Causes. Mill himself subscribes to this doctrine.

This doctrine goes against the scientific conception of cause. Science believes that the same cause will produce the same effect. Plurality of causes is a false doctrine arising from a confusion between general and particular stand points. Take the familiar example. We say that death has many causes because we take the effect *viz.* death in the general or abstract sense and the cause in the particular or concrete sense. This is wrong. We must take both cause and effect in the same sense, i. e., both in the general sense or both in the particular sense. In either case we will find that plurality of causes disappears and that there is only one fixed cause for one effect. Thus if we take death in the general sense, there is only one general cause of death *viz.*, the heart ceasing to function. Or, if we speak of several particular causes of death, we will find that each of these causes has its own particular effect. If drowning is the cause, it will produce death by drowning. Similarly hanging will produce death by hanging. In every case only the same cause produces the same effect. It has been rightly said that "plurality of causes is due to failure in analysis and disappears with scientific investigation",

Mill is inconsistent. He supports Plurality of Causes. He also believes that the same cause produces the same effect.

5. Composition or Conjunction of Causes and Inter–Mixture of Effects

Two or more independent causes may combine to form a compound cause and this may produce a compound effect or a joint effect. For example, A, acting alone may produce M; B, acting alone may produce N. The two causes may combine into a joint cause AB. This is known as the composition or conjunction of causes. The effect of this is not either M alone or N alone but a mixture of MN. This is known as intermixture of effects.

The intermixture of effects may be homogeneous. or heterogeneous. Homeogeneous intermixture means the joint effect is of the same kind as the separate effects. That is the joint effect of two electric bulbs is only a more intense light than the separate lights of the two bulbs. Heterogeneus means the joint effect is wholly different in kind from the separate effects. This kind of intermixture is found in chemical changes. E. g., Oxygen and Hydrogen combine to produce water. Here no trace of the properties of the combining gases is found in water.

6. Fallacies of Causation

1. *Post hoc ergo proptor hoc* (after this, therefore on account of this): Example : The waving of the juggler's wand was the cause of the appearance of the snake, because the snake appeared the moment the juggler waved his wand.

2. *Mistaking a condition for the whole cause*: Example : In the last two examinations, the percentage of passes has been very low. Therefore the teachers in the various colleges must be incompetent.

3. *The fallacy of regarding the co-effects of a common cause as cause and effect:* Example *:* Since night invariably precedes day, it is the cause of day.

4. *The fallacy of false cause :* This is the fallacy of regarding something wholly unconnected with a phenomenon as its cause. Example : He must be an excellent man for he talks so well.

5. *Reciprocity of cause and effect :* Two phenomena may be related in such a way that each is the cause of the other. Hence it is not possible to say which is the cause and which is the effect. Example : Drink must be the cause of poverty for most poor people drink ; beating and crying.

6. *Mistaking constant conjunction for causal connection* **:** Two phenomena may be found to exist together. But the mere fact that they are found together does not prove that they are causally connected though it may suggest a causal connection. Example *:* Poverty must be the cause of the increase of population for we find that all poor countries are thickly populated.

XI. MILL'S EXPERIMENTAL METHODS

Sec. 1. Introduction
Sec. 2. The Method of Agreement
Sec. 3. The Method of Difference
Sec. 4. The Joint Method of Agreement and Difference
Sec. 5. The Method of Concomitant Variations
Sec. 6. The Method of Residues
See. 7. A general estimate of Mill's methods.

1. Introduction

John Stuart Mill (1806-1873) based his theory upon the Law of Universal Causation. For him causal laws are types of invariant relations. A cause is an unconditional, invariant, antecedent, and experimental inquiry was the method of discovering these invariable relations between events. For this purpose he formulated five methods of experimental inquiry. They are:

1. The Method of Agreement.
2. The Method of Difference.
3. The Joint Method of Agreement and Difference.
4. The Method of Concomitant Variations.
5. The Method of Residues.

These methods are also known as *Inductive canons, Experimental methods or Experimental canons.* These methods are also called *direct methods* since their aim is to establish causal connection between phenomena by direct observation and experiment.

The methods accomplish the task of discovering the causes of phenomena by a process of elimination. Mill's canons aim at establishing the irrelevant circumstances, in order to find out those which are causally connected. Suppose C is the cause of P. C does not occur alone, but is combined with A, B, D, etc. Similarly P is combined with W, X, Y. In this case, how are we to find out that C is the cause of P or that P is the effect of C? We can do it by varying the circumstances, A, B, D and W, X, Y-that is, eliminating them we find that whenever C is, P is; and whenever C is absent P is absent. Therefore, *Mill's methods are methods of elimination.*

The following are the rules of elimination as set forth by Prof. Joseph:

1. That is not the cause of a phenomenon which is absent when the phenomenon is present.

2. That is not the cause of a phenomenon which is present when the phenomenon is absent.

3. That is not the cause of a phenomenon which varies when it is constant or constant when it varies or varies in no proportionate manner.

4. That is not the cause of a phenomenon which is known to be the cause of another phenomenon.

These rules of elimination turn upon two leading ideas (a) That cause and effect must be present and absent together and (b) that there is quantitative correlation between them.

The five methods of Mill involve the application of the principles of elimination. The Method of Agreement employs the first of the four principles. The Method of Difference is based on the second principle. The Joint Method of Agreement and Difference is a combination of the first two methods. The Method of concomitant variations makes use of the

third principle of elimination. And the Method of Residues applies the last rule of elimination. Thus we find that all Mill's canons of the methods can be ultimately deduced from the principle of causation. We may now give an account of these methods one by one.

2. The Method of Agreement

(i) *Canon:* "If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon".

(ii) *Symbolic illustration:* Let P_1, P_2, P_3 be the three instances of the phenomenon P. Let us suppose that the antecedents of the phenomenon in each of these instances are as follows:

Antecedents	Instances of the phenomenon
A B C	P_1
D E C	P_2
F G C	P_3

We find that all the antecedents except C are sometimes absent. They are not invariable. 'That is not the cause of a phenomenon in whose absence the phenomenon occurs'. By applying this rule we eliminate all these variable antecedents. C is the only antecedent which is present in all the three instances. Therefore, according to the canon of this method C is *probably* the cause of P.

(iii) *Concrete illustration:* Cholera breaks out in a town and the public health authorities want to find out the cause of the spread of the disease. They take a few instances of the case and inquire into the antecedents like water-supply, vegetables, fruits and milk. Supposing it is found that the houses which are attacked by the disease got their milk, vegetables and fruits from widely different sources while all of

them get their water from the same source, the public health authorities will naturally conclude that probably water is the cause of cholera in the town.

(iv) *Merits :* (a) This is an observational method. Therefore it can be applied in many fields. Again, it can be used to find out causes from effects and effects from causes.

(b) It suggests hypotheses like simple enumeration and analogy.

(v) *Defects :* (a) Conclusions reached by this method are only probable because the method does not provide for the verification of the hypothesis which it suggests.

(b) In some cases this method may even mislead us. For example,

Poison A + Water Produces Death
Poison B + Water Produces Death
Poison C + Water Produces Death

Here, the poisons differ; water is the common antecedent. Therefore according to this method water is the cause of death. This is absurd.

(c) This method is helpless against an apparent plurality of causes. It may suggest that C is the cause of P. But it does not prove that C is the only cause and that there is no other cause for P. This is because this method does not consider negative instances. That is, it does not show that whenever C is absent P is also absent. It considers only positive instances.

(d) In actual practice it is very difficult to secure two or more instances which agree only in one circumstance as this method requires. Moreover, it is not possible to separate the antecedents and state them in a clear-cut manner. In natural phenomena the antecedents are always intermingled.

(e) This method is in search of a single invariable antecedent. Therefore it commits the fallacy of mistaking a condition for the whole cause.

(vi) *Method of Agreement and Simple Enumeration*: *Similarities.*

(a) Both are observational methods.
(b) Both depend on a number of instances.
(c) Both suggest hypothesis.
(d) Both give only probable conclusions.

Differences : (a) Simple Enumeration collects only similar instances. But the method of Agreement carefully selects differing instances.

(b) SE does not at all analyse the instances. Its conclusion is based on mere counting. But MA analyses the antecedents, eliminates irrelevant antecedents and it finds out the only invariable antecedent.

(c) Hence SE is less scientific and MA is more scientific.

Exercise : Intermitent fever is found only in places where there are marshes even though they differ in every other respect. Therefore marshes are the cause of intermittent fever.

3. The Method of Difference

(i) *Canon* : " If an instance in which the phenomenon under investigation occurs, and instance in which it does not occur, have every circumstance in common save one, that one occuring only in the former ; the circumstance in which alone the two instances differ is the effect, or the cause, or an indispensable part of the cause, for the phenomenon ".

This method requires two instances, one positive and the other negative. The canon states that the two instances should agree in all circumstances except one. Nature does not give us such instances. We have to produce them and so this method is experimental.

The value of taking a negative instance is that it helps to verify whether the supposed cause is really the cause. Positive

instances can only suggest that a circumstance is probably the cause of a phenomenon. But if the circumstance is really the cause of the phenomenon, it should be absent in instances where the phenomenon is absent. C and P may be present together in hundreds of instances. But if C is present even once when P is absent, then C cannot be the cause of P. So the negative instance is very important.

(ii) *Symbolic illustration :*

	Antecedents	Consequents (Phenomenon)
Positive instances	A B C	P Q R
Negative instances	A B	Q R

"That is not the cause of a phenomenon in whose presence the Phenomenon fails to occur'. By applying this rule we eliminate A and B. By comparing the two instances we conclude that C is causally connected with P.

(iii) *Concrete illustration :* If a bell is rung in a jar containing air, the sound is heard. But after having removed the air by means of an air pump, let the bell be struck again. The sound is no longer heard. When the two instances are compared, it is at once evident that the only difference in the antecedents is the presence of air in the one case and its absence in the other. All other circumstances remain the same. When the air is present, the sound is heard; when it is absent, the sound is not heard. We, therefore, conclude that the presence of air is causally connected with the propagation of sound.

(iv) *Merits :* (a) This method has all the advantages of experiment.

(b) A negative instance helps us to verify a hypothesis. We obtain absolutely certain conclusions. Thus it is an improvement on the Method of Agreement.

(v) *Defects :* (a) This method cannot be applied where experiment is not possible, for e. g., social phenomena.

(b) This method does not completely overcome plurality of causes.

(c) Sometimes this method misleads us into thinking of a single condition as the whole cause. Salt added sambar is tasty. When salt is not added, sambar is not tasty. But this does not mean that salt is the whole cause of the taste.

(d) Since this is an experimental method, it cannot be directly applied to find out causes from effects.

(e) It is not able to cope with permanent causes, such as the force of gravitation, for they cannot be eliminated.

(vi) *Conditions* : (1) Only one circumstance should be varied at a time.

(2) No time should be lost in passing from the positive to the negative instance or vice versa.

(3) To eliminate the effect of unknown factors, the experiments must be made by different persons under different circumstances.

Exercise : When a coin and a feather are dropped simultaneously in the receiver of an air pump, the air being left in, the feather flutters to the bottom after the coin ; but when the air is pumped out of the receiver, the coin and the feather, being dropped at the same instant, reach the bottom of the receiver together. Hence the resistance of air is the cause of the feather falling more slowly than the coin.

4. The Joint Method of Agreement and Difference

(*i*) *Canon* : "If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common, save the absence of that circumstance, the circumstance in which alone the two sets of instances differ is the effect, or the cause, or an indispensable part of the cause, or the phenomenon ".

This method examines two sets of instances, one positive and the other negative. It shows that one and the same circumstance is uniformly present in the positive instances and is uniformly absent in the negative instances. There is agreement in the presence and agreement in the absence of the same circumstance. Hence this method is called *the Method of Double Agreement.* This method applies the first two rules of elimination.

(ii) *Symbolic illustration:* Positive instances, i.e. instances in which the phenomenon P occurs.

Antecedents	Instances
A B C	P_1
D E C	P_2
F G C	P_3

'That is not the cause of a phenomenon in whose absence the phenomenon occurs'. By applying this rule, we eliminate all the antecedents other than C. C is the only antecedent which is uniformly present. Hence C is probably the cause of P.

To verify and confirm this conclusion we take negative instances, i. e, instances in which the phenomenon P does not occur. (The negative instances should be taken from the same field from which the positive instances are taken.)

Antecedents	Instances
A B	1
D E	2
F G	3

'That is not the cause of a phenomenon in whose presence the phenomenon fails to occur'. By applying this rule we eliminate all the above antecedents. C is the only antecedent which is uniformly absent when P is absent.

Thus whenever C is present, P occurs and whenever C is absent, P does not occur. Hence C is the cause of P.

(iii) *Concrete illustration:* Whenever mosquitoes of a particular type are present, malaria is present; and whenever they are absent, malaria is also absent. Therefore the presence of these mosquitoes is the cause of malaria.

(iv) *Merits:* (a) This method combines the Method of Agreement and the Method of Difference. So it has the merits of both these methods minus their defects.

(b) This is an observational method and so it has a wide scope. Besides, it can be worked from cause to effect and vice versa.

(v) *Defects:* (a) Since this method relies on observation it does not give absolutely certain conclusions.

(b) This method requires that only one circumstance should be uniformly present in the positive instances and uniformly absent in the negative instances. This is not easy to obtain.

(c) Unless the negative instances are perfect a d exhaustive, this method cannot overcome plurality of causes.

(d) Sometimes this method mistakes a single condition for the whole cause.

Exercise: Whenever I take tea at night, I suffer from sleeplessness. I find that if I avoid taking tea at night, I am able to sleep well. Obviously tea is the cause of my sleeplessness.

5. The Method of Concomitant Variations

(i) *Canon:* "Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon, or is connected with it through some fact or causation."

If two things are related as cause and effect, any variation in one of them must be accompanied by a proportionate variation in the other. Phenomena which vary concomitantly must certainly be causally connected. The variations may be in the direct or inverse ratio. The rule of elimination which this method applies is 'That is not the cause of a phenomenon which varies when it is constant, or is constant when it varies, or varies in no proportionate manner with it.'

(ii) *Symbolic illustration :* Variations in C are accompanied by corresponding variations in P. Hence we conclude that C and P are causally connected.

C_1	P_1
C_2	P_2
C_3	P_3
C_4	P_4

(iii) *Concrete illustration :* (a) If we rub one substance against another, heat is produced. The greater the friction, the greater is the amount of heat. From this Joule concluded that friction is a cause of heat.

(b) The more a body is heated, the more does it expand. Therefore heat is the cause of expansion.

(iv) *Merits :* (a) The first three methods of Mill can suggest that one thing is the cause of another. But the method of Concomitant Variations can go further to find out the exact quantitative relation between cause and effect.

(b) This method is both observational and experimental. Where observation alone is possible, this method can suggest a causal connection. Where experiment is possible, it can also verify and confirm a causal connection.

(c) Permanent causes like the force of gravity on atmospheric pressure cannot be completely eliminated. In such cases the Method of Difference cannot be employed because we cannot have negative instances. The method of

concomitant variations alone can deal with permanent causes. For, they can be studied only in their varying degrees.

(v) *Defects :* (a) In some cases the two phenomena which vary concomitantly may not be causally connected. They may be the co-effects of a common cause, *e. g.*, lightning and thunder.

(b) This method can work only within certain limits. The more water is cooled, the more does it contract, but not below a certain temperature.

The method of C. V. may be regarded as an extension of the method of Difference for two reasons : (1) It gives additional precision to the causal connection already discovered by the method of Difference. By the method of Difference we find that air is necessary for the transmission of sound. The method of C.V. can carry the same investigation further. By varying the quantity of air and nothing the loudness of the sound, it can show the exact proportion between the two. (2) Where it is not possible to eliminate a circumstance completely (*e. g.*, gravity) and thus secure a negative instance, the method of Difference is helpless. It has to seek the aid of C. V. which varies the circumstance and studies the effects of the variation.

Exercise : The scarcity of food grains in the country is due to the lack of facilities for transport, for we find that scarcity of food grains increases when the difficulties of transport increase.

6. The Method of Residues

This method is based on the following rule of elimination. 'That is not the cause of a phenomenon which is know to be the cause of another phenomenon.'

(*i*) *Canon as given by Mill :* "Subduct from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents".

(ii) Symbolic illustration : Let us suppose that CDE are the antecedents of a phenomenon PQR. Suppose by previous inductions we have known that Q is the effect of D, and R is the effect of E, then according to the canon, P is the effect of C.

(iii) Concrete illustration : A student lights his lamp at night and studies for two hours. At the end of two hours he finds that the temperature in his room has risen by 5 degrees. The increase in the temperature must be due to tht heat of the lamp and the heat given off by his body. If we know that the heat of the lamp increases the temperature by four degrees, then by the simple process of subtraction, we can infer that the remaining one degree is due to the heat given off by his body.

The method as stated by Mill above applies to a complex phenomenon resulting from several causes acting jointly. It then enables us to determine what part each of these causes plays in producing the total effect. But there is also another case in which this method can be applied. Mill did not know this. It can be applied where any part of a phenomenon is still left unexplained.

(iv) *Mellone gives the following canon:* "When any part of a complex phenomenon is still unexplained by the causes which have been assigned, a further cause for this remainder must be sought".

(v) *Symbolic illustration :*

? DE............PQR.

The known antecedents of PQR are D and E. D is the cause of Q and E is the cause of R. P is the unexplained residue of the phenomenon. We have to find out the cause of P.

(vi) *Concrete illustration :* The greatest achievement of this method is the discovery of the planet Neptune.

Astronomers found that the planet Uranus moved further away from the path along which it ought to have travelled. This residuary phenomenon. viz., the deviation from the

calculated path remained unexplained for 60 years. Further research suggested that it might be due to the attraction of an unknown planet. Observations were made and the new planet Neptune was discovered.

(*vii*) *Merit* : The attempt to explain residuary phenomena has led to many scientific discoveries.

(*viii*) *Defect* : (a) This method will not be useful at the initial stages of an inductive inquiry. Only after a major portion of a complex phenomenon has been explained by other methods, can this method be employed to explain the residue.

(b) The Method of Residues as applied by Mill is deductive in character. It is not an inductive method. It depends on previous inductions. It proceeds by the process of subtraction which is a purely deductive process.

(c) The method as applied by Mellone is not a method at all. It simply urges us to carry out further inquiry and find out the cause of the residue. It says nothing about the method of inquiry.

Exercises : (1) Water is jointly conveyed into a tank by three pipes of unequal size at the rate of 10 gallons per minute. It is known that the first two pipes together admit water at the rate of 7 gallons per minute. Therefore the amount of water admitted by the third pipe is at the rate of 3 gallons per minute.

(2) Lord Rayleigh detected a diffierence of half per cent in the density of Nitrogen as prepared from Ammonia and as extracted from the air. This led to the discovery of a new element, the inert gas known as Argon.

7. A General Estimate of Mill's Methods

Mill's experimental methods help us to discover causal connection between phenomena. But Mill makes two extravagant claims.

(1) Mill claims that these methods are the only possible forms of inductive reasoning. This is a very tall claim. There are also many other forms of inductive reasoning. Just as it is wrong to say that the syllogism is the only form of deductive reasoning, it is wrong to say that Mill's methods are the only forms of inductive reasoning. Mill's method deals only with causal relationship. But induction is not limited to the study of causal relationship. In sciences like Biology we study other kinds of relation between things.

(2) Mill claims that his experimental methods are the model for all inductive arguments. He says that these methods have laid down rules which have to be strictly followed by all inductive arguments if they must be valid. This is absurd. Thinking, whether it is inductive or deductive, cannot be made to follow any fixed rule. It has to adopt itself to the nature of the object which is thought about. Moreover, what we call as rules and laws of thinking are not laid down in advance.

Defects of Mill's Methods

(1) These methods cannot by themselves establish a causal relationship. They cannot function unless some preliminary study and analysis has been done. It is only after we have analysed the circumstances and sugested hypotheses as to the probable cause that we can apply these methods.

(2) The procedure of these methods is somewhat artificial. They require that the antecedents should be separated and stated in a clear cut manner, such as A, B, C etc. Similarly the consequents. But in nature the various antecedents and similarly the various consequents are often mixed up and inseparable. Further, natural phenomena rarely satisfy the conditions demanded by these methods, such as, having only one circumstance in common, having every circumstance in common save one, etc.

(3) None of these methods completly overcomes the difficulty of plurality of causes.

(4) It appears that there are five independent method. But really it is one and the same principle that underlies all of

them, viz., the Principle of Elimination. In all these methods the results are reached by eliminating the unessential circumstances. Hence Mill's methods are called Weapons of Elimination.

(5) These methods are really deductive and not inductive. They proceed from the general principle of causal relation to its application in a particular case. Their procedure may be represented in the form of a syllogism :—

Phenomena which are present and absent together and which vary concomitantly are causally conncted.

C and P are phenomena which satisfy those conditions.

Therefore, C and P are causally connected.

(6) Finally it is misleading to call these methods experimental. The method of agreement is essentially observational. And the other methods can very well be applied in phenomena which are outside the scope of experiment.

XII. STATISTICS AS AN ENUMERATIVE METHOD

Sec. 1. What is Statistics ?
Sec. 2. The Class of Facts to which the Statistical Method is employed has two characteristics
Sec. 3. Conditions for the Right Use of Statistics
Sec. 4. The Results of Statistics are Usually Stated in Four Ways
Sec. 5. The Uses of Statistics
Sec. 6. The Defects of Statistics
Sec. 7. Calculation of Chance or the Theory of Probability

1. What is Statistics?

If the counting method is placed on a scientific footing, it is called Statistics. The aim of Statistics is to make the process of counting as exact and precise as possible. In Statistics, we collect a large number of instances but, unlike in simple enumeration, here the instances are of different types.

Statistics is very useful in phenomena where experiment is not possible. For, in such phenomena, analysis is difficult and in order to facilitate analysis we have to observe a great variety of instances.

2. The Class of Facts to Which the Statistical Method is Employed Has Two Characteristics

(1) The subject dealt with is complex and at the same time capable of division into a number of individual parts or units. Thus statistics is employed to study complex social problems like unemployment, illiteracy, labour conditions, etc.

(2) The subject dealt with is one whose underlying cause or law is unknown. For example, statistics is employed in order to forecast earthquakes. The real cause of earthquakes is still unknown. Hence the only method by which we can predict the shocks that will occur in the future years is to collect statistical data regarding the shocks that have occurred in the past so many years.

3. Conditions for the Right Use of Statistics

(1) The complex phenomenon that we study must be capable of being divided into a number of parts and counted. e. g., unemployed people into different categories.

(2) The Unit of Counting must be clearly defind. e. g., Before collecting data on unemployment we have to define who an unemployed person is.

(3) The enumeration must be restricted to a specific period and area.

(4) Information must be obtained on a number of allied topics. e. g., in census enquiry the authorities record not only the number of persons in each house but also the numbers of males and females, adults and children, occupation of the members and so forth.

(5) Statistical data must be collected for a definite purpose. The enumeration of facts must not proceed in an aimless manner. If all these conditions are observed, 'figures will not lie', that is, Statistics will give accurate results. The violation of these conditions will lead to false results which are called 'the Statistical Lie'.

4. The Results of Statistics Are Usually Stated in Four Ways

(1) *The Average:* This is also known as the Arithmetical Average, the General Average, the Mean or the Arithmetical Mean. This is obtained by adding up the value of the group and dividing the aggregate by the number of individuals in the group. e. g., Total marks of a class of 40 students is 2,000. So

the average mark of the class is 2,000 is divided by 40, *i. e.* 50. The average gives us a general picture of the level reached by a group. But it is an imaginary figure which does not indicate the level of any particular individual in the group.

(2) *The Mode:* This is the position which occurs most frequently in a group.

(3) *The Median Value:* This is the phenomenon which occurs somewhere in the middle in a group when it is arranged according to some scientific principle. This is employed in Botany and Zoology.

(4) *The Weighted Average:* To obtain Weighted Average multiply the units by certain 'weights' and then add them. The sum, thus obtained is divided by the sum of weights. For example, a student gets 70%, 55%, and 46% in Logic in the first, second and third examinations respectively. These examinations differ in importance. We give special consideration or weightage to each of them. We may give one unit of importance (weightage) to the first examination, two units to the second and three units to the third. Thus the weighted average of the marks is :

$$\frac{(70 \times 1) + (55 \times 2) + (46 \times 3)}{1 + 2 + 3} = \frac{318}{6} = 53$$

5. The Uses of Statistics

(1) Accurate description is difficult when we deal with a complex phenomenon which involves a large number and variety of facts. Statistics helps us to acquire a clear and comprehensive grasp of facts. By systematic counting and classification, statistics enables us to know the extent and variety of a complex problem. For example, the method of statistics is employed in studying the problem of unemployment. The facts are classified under separate heads like educated and uneducated, men and women, skilled and unskilled and so forth. Thus we get a fairly good idea of the scope and extent of the problem Thus statistics makes description fairly exact and trustworthy. This is *the descriptive use of statistics.*

(2) Close examination of the facts collected and classified by statistics may sometimes suggest hypothesis. Thus statistics is highly useful in the work of explanation because it is able to suggest hypotheses. It makes us guess causal connections between group of facts. It does this in two ways :—

(*a*) *By revealing a quantitative correspondence between facts :* If two phenomena vary together either directly or inversely, we may suspect a causal connection between them. Example : We compare the statistical figures about the prices of commodities with figures relating to the number of thefts in the district. Supposing we find that with every increase in prices, there is a corresponding increase in thefts and with every decrease in prices the number of thefts also decreases, we begin to think that there is probably a causal connection between prices and thefts. Or again, if we find that when production of articles goes up, their prices fall and when production decreases, the prices rise up, we suspect a causal connection between the two phenomena.

(*b*) *By revealing a striking departure from the normal :* A college has the statistics of the percentage of passes in the University Examination in the past many years. On an average nearly 80% used to pass every year. One year it so happens that the percentage suddenly falls. Only 40% have passed. This is a striking departure from the normal. There must be some special cause for this unusual fall. The authorities undertake a thorough enquiry to find out the cause. They recall to their minds the main events of the year, eliminate them one by one and finally presume one of them to be the cause, i. e., constant closure of the college due to student strikes.

In these two ways statistical data when closely examined reveal causal connections. By revealing these connections statistics renders our knowledge systematic. This is *the explanatory use of statistics.*

(3) Where we are ignorant of the causes that are at work, the only way in which we can predict coming events is by means of statistics. By giving us the average in the past years or large numbers of things or events, statistics enables us to

judge more or less accurately what will happen in the future. This is how earth-quakes, for example, are predicted. Again, this is how governments plan their Budgets for coming years. It has been rightly said that statistics are the only candles which light up the darkness of the future. This is *the predictive use of statistics*.

6. The Defects of Statistics

(1) Statistics can only suggest a hypothesis. There is no provision in the method of statistics for the verification of the suggested hypothesis. Hence its conclusions are only probable.

(2) Statistics may sometimes mislead us. It will suggest that two phenomena which vary together are related as cause and effect. But after all they may be the co-effects of a common cause which is not revealed by statistics. e. g., population and poverty.

(3) Statistics is a double-edged weapon. Statistics can be gathered to prove a certain conclusion. Other statistics, equally reliable, may be collected to disprove this conclusion.

7. Calculation of Chance or the Theory of Probability

What is chance?: When we do not know the cause of an event, we say that it happens by chance or accident. Thus the term "chance" simply denotes our ignorance of the causes of events, but it does not mean that there is no cause.

With the aid of statistics, we can calculate chance on the probability of occurrence of the phenomenon. This is known as the calculation of chance. It is also known as the theory of probability

Examples

(1) Suppose a coin is thrown up, we do not know whether the head will appear or the tail. If a coin is thrown 20 times, we may expect the head to appear 10 times. In other words, the probability or chance of the head is 10/20 or 1/2. It is also known as the mathematical chance or the expected

chance. This may not actually happen in a few throws. But when the number of throws is sufficiently large the expectation may come true. For e.g., in the experiment conducted by *Jevons* out of 20,480 times, head appeared 10,353 times, i. e. nearly half.

(2) The success of the Life Insurance Corporation, for example, depends on the calculation of chance. Insurance business involves risk. If a policy-holder dies before he completes his expected period, the Corporation has to pay back to his nominees the full amount for which he has insured his life. The corporation has to be prepared to meet such losses due to premature deaths. Hence what the Corporation does is to collect statistical data regarding the number of premature deaths, each year over the past so many years. On the basis of these data, the Corporation can foresee more or less accurately how many are likely to die in the coming years and consequently what the probable loss would be. Then it makes adequate provisions to meet the expected loss by collecting an extra amount from all its policy-holders. Thus chance is almost completely eliminated

The value of the Theory of Probability or Calculation of Chance in scientific investigation is the discovery of hidden causes. e.g., If a coin is thrown up, the expected chance of the head is 1/2. But if in a number of throws the head appears very few times, we may suspect that there must be a special cause acting against the falling of the head. This suspicion provokes investigation which may ultimately lead to the discovery of the cause.

XIII. INDUCTIVE FALLACIES

A. Fallacies Due to Careless Use of Language

Bacon calls these 'Idols of the Market place'. Language is the vehicle of thought. Words and phrases should, the refore, be chosen with great care so as to express our thoughts accurately. Very often we come under the spell of words and phrases. We are eager to use them without knowing exactly what they mean. There are three forms:

(1) The Fallacy of Equivocation: This consists in using a term in more than one sense.

(2) The Fallacy of using Question, Begging Epithets and cant phrases. These are devices employed by clever politicians to carry the crowd with them. A question begging epithet is a word or a phrase which assumes the point to be proved. Slogans and catch-word words are of this type. By using such epithets a clever speaker may prepare the mind of the audience in favour of or against a cause even before proving that the cause is good or bad. Examples :- 'People's cause', 'Unconstistutional', 'Undemocratic', 'Retrograde and Reactionary', 'Medieval', 'Imperialist'.

Cant words and phrases are insincere and hypocritical expressions which are made simply to win the support of crowd, e.g., 'World-peace', 'Equality, Freedom and Justice'. These expressions are often used without any real intention to pursue them.

B. Errors of Observation

(1) Non-observation
(2) Mal-observation

C. Mistakes in Reasoning or Explanation

(1) Hasty generalization. This is the fallacy of reaching a generalization on the basis of a very few instances which are

only counted and not analysed. Example: That town must be unhealthy, for I know three people who live there and all of them are unhealthy.

(2) Unsound analogy.

(3) Fallacies of causation.

D. Fallacies Due to Prepossessions or Prejudices

(1) *Idols of the Cave:* Bacon gives this name to the Limited outlook which different individuals have on any problem. A mathematician's outlook on the world is sure to be different from that of a historian. A lawyer's reaction to a public question is sure to be different from the reaction of a doctor on the same question. One's approach to every question is limited by his profession, his past training and so on. He is like a horse in blinkers and cannot take a wider view of things. Even scientists and philosophers suffer from this natural limitation.

(2) *Idols of the Theatre:* Just as particular individuals have their own special outlook, even so a whole age may have its own special outlook. Every age is dominated by certain ideas. This is called the time spirit or 'Zeit geist'. For e.g., the 18th century was powerfully influenced by the idea of the machine. Men of that age conceived of everything as a machine. The world itself was looked upon by them a a huge machine. The 19th century was largely dominated by the Theory of Evolution.

A note on the 'Idols' of Bacon: Idols are prejudices that prevent a man from understanding correctly, cloud his vision and conceal the truth. They are:

(1) *Idols of the Market Place:* (Fallacies due to careless use of language)

(2) *Idol of the Tribe:* (Non-observation)

(3) *Idols of the Cave:* (Fallacies due to prepossessions of an individual)

(4) *Idols of the Theatre:* (fallacies due to prepossessions of a whole age).

XIV. DEDUCTION AND INDUCTION

Reasoning includes (i) The premises or data or evidence or ground and (ii) the conclusion or the inference. Reasoning or infernce is either deductive or inductive. If reasoning takes the form of drawing conclusions from evidences which are taken for granted, it is deductive. On the other hand, if reasoning starts from observed facts and tries to discover their nature, it is inductive.

Let us illustrate the two types of inferences by taking examples. We say that if a cricket ball is thrown up, it will be gravitated because we take it for granted or assume that all material bodies gravitate. Hence we assume the truth of the statement "All material bodies gravitate" and the conclusion that 'The cricket ball will be gravitated' necessarily follows from the premise. In other words, here the premise implies the conclusion. If the premise implies the conclusion, the inference is called *Deductive*. But what is the ground for the belief that "All material bodies gravitate?" As evidence we point out the observed particular facts such as a fruit falling to the ground, an aeroplane which has developed engine trouble falling to the ground, a stone thrown up falling to the ground and so on. Here we are finding evidence in the form of particular facts of experience. But the evidence in the form of particular facts is not certainly conclusive because we cannot observe all material bodies falling to the ground. The conclusion "All material bodies gravitate" is not contained in the information that the material bodies so far observed have been gravitated.

If the conclusion in an inference is based on particular acts of experience, the reasoning is called Inductive. While deduction is necessary reasoning based on premises which are taken for granted, induction is general reasoning based on

observation of particular instances. In both the processes we produce reasons for what is asserted. To find out or to discover that 'All material bodies gravitate', we produce evidence or reason in the form of particulars. To prove that the cricket ball will be gravitated, we produce evidence or reason in the form of a general statement that all material bodies gravitate. In both the processes we proceed from the premises to the conclusion. If we proceed from the particulars (premises) to the universal (conclusion), it is *Inductive*; and if we proceed from the universal (premise) to the particular (conclusion) it is *Deductive*. Thus logic, which is the Study of Inferences, is organised into two fields-Deduction and Induction. Deduction comprises of the various methods of proof and it means "the process of leading down". Induction comprises the various methods of discovery and it means "The process of leading into".

In Deduction we make use of a universal proposition. For example; in a syllogism we apply a general principle to a particular instance.

All men are mortal beings.

Rama is a man.

∴ Rama is a mortal being.

In Deduction we merely accept such universal proposition as "Water boils at 100°C at sea level", "All material bodies gravitate" as true. We do not inquire how they are derived or where from we get them. But in Induction we study the method of thinking by which we infer a general proposition. Further, in Deduction we are interested in the formal validity of an argument. In it we do not inquire whether the argument is true or false, that is, whether it agrees with the actual facts of experience or not. Deduction is the process of formal proof. In it the truth of the propositions composing the argument is not particulary in the foreground. The propositions, in deduction, are regarded as being purely formal. Validity is the chief aim of Deduction. For example, the following inference according to Deduction, are valid.

Example I

All men are angels. Therefore, no men are non-angles. Though this inference is not true, it is correct or valid because no rule of obversion is violated here.

Example II

All men are those who have wings.

Raju is a man.

∴ *Raju is one who has wings.*

This argument also, though not true, is deductively valid, for it does not violate any rule of the categorical syllogism. That is, being valid deductively is different from being materially true (i.e. true to reality). Validity is linked with the form of inference, while truth with the matter of inference. Formal validity of an argument consists in the correct arrangement or sequence of statements; the material truth of an argument consists in the premises being true statements of facts. We are not satisfied with mere formal validity. We want to know whether an argument is materially true or not. Here again we turn to induction which is another word for experience, which guarantees to the truth of an argument.

The two forms of thought are not opposed to each other. Induction is inference involved in reaching generalizations while Deduction is inference exemplified in applying generalizations to particular cases. Generalization is the concern of induction. Demonstration (proof) is the concern of deduction. Each supplements the other. Deduction depends on Induction for the general proposition. Similarly Induction depends on Deduction to prove the general law. Inductive hypotheses have to be verified and tested by Deductive application. Thus Induction and Deduction are two aspects of one and the same process, namely, thought. Knowledge consists of ideas about facts related to each other. The facts lead to laws and the laws are verified by facts. If we start from facts it is Inductive. If we start from laws it is Deductive. Facts and laws are not different. Facts contain the laws and the laws are discovered from facts. The

particulars are instances of a universal law and the universal law is the principle underlying the particular facts.

All reasoning when fully stated has both a formal aspect and a material content. While Deduction testifies to the formal aspect of reasoning, Induction guarantees to the material content.

To conclude we may quote from A.A. Luce "As a logical process, Induction leads the mind on from fact to fact, like a working bee passing from flower to flower; while Deduction, like the spider draws down thread from thread, and weaves its web. The two processes meet at the General Proposition".

XV. INDIAN LOGIC

Sec. 1. Introduction.

Sec. 2. Svartha Anumana and Parartha Anumana.

Sec. 3. Syllogism—Three or Five Membered and Three Termed.

Sec. 4. The Five Membered Syllogism of the Nyaya—Naturalistic Syllogism.

Sec. 5. Critics of the Five Membered Syllogism.

Sec. 6. Nyaya Syllogism—Defended.

Sec. 7. Terms.

Sec. 8. Vyapti—The Ground of Inference.

Sec. 9. Classification and Logical Forms of Inference (Nyaya).

1. Introduction

Literally, *anumana* means knowing after. *Mana* means a measure. In the present context, it means a measure of knowledge. The prefix *ANU* indicates that this (means of) knowledge is not self-sufficient. *Anumana* means the method by which knowledge is derived from another knowledge. This refers to the logical process of gaining the knowledge. The knowledge thus gained, that is, inferential knowledge, is called *anumiti*, literally 'the consequent knowledge' (from *anu* after, and *Miti* knowledge). It means knowledge that follows from another knowledge. That is *anumana* depends on some other measure of valid knowledge. If *anumana* relates to mundane matters, it depends on perception and if it relates to supersensous matters, it depends on valid testimony (*sabda*).

Inferential knowledge is the knowledge that is derived from the knowledge of an invariable relation between what is perceived and what is deduced. The Sanskrit term for this relation is *Vyapti* (literally extension or pervasion). In Western Logic it is called the invariable concomitance. The core of inference (*anumana*) is the knowledge of invariable concomitance (*vyapti*) which is gained from experience. The sanskrit term *anumana,* though it denotes inferential knowledge, is generally used in the sense of its method or process.

The *Naiyayikas* i. e. the Indian dialecticians have taken the lead in the systematic study of inference. Their methods of reasoning and terminology have considerably influenced the logic of other systems. But though there are agreements among the Indian schools as to the general principle of inference, yet there are sharp differences as regards its particulars. They all agree that the key to inference is the knowledge of invariable concomitance *(Vyapitjnana).* But they differ as to the exact meaning of *Vyapti,* the way its knowledge is attained and the method of reaching conclusion through this knowledge. The Buddhist way of determining the *Vyapti,* differs from the ways of the *Naiyayikas* and the *Advaitins.* There are also divergent views as to the classification of inference. We shall note some of these agreements and disagreements as we proceed.

2. Svartha Anumana and Parartha Anumana

The *Naiyayikas,* and the *Advaitins* agree on the two fold classification of inference. (a) *Svartha* means for oneself and (b) *Parartha* means for others. This distinction is more psychological than logical. If it is a matter of convincing oneself of the truth of any matter one can dispense with the external forms of reasoning. One can satisfy oneself without going through all the appurtenances of proof. At one bound, a man can perceive the central truth that lies hidden in the midst of several adventitious elements. It depends upon one's quickness of grasp and ability to go to the heart of the matter. If one can reach the conclusion straight way one can easily

dispense with the forms of rigorous proof. When one is convinced of a truth intuitively, he takes the earliest occasion to place it before others for their acceptance. When it is a case of convincing other people, it is quite, necessary to go through all the forms of proof.

3. Syllogism—Three or Five Membered and Three Termed

To demonstrate the truth of the conclusion to others, a formal statement of reasoning process, that is to say, a syllogism is required. According to the *Advaitins* (and also *Mimamsakas*) a syllogism consists of three steps or propositions. According to the *Naiyayikas* (and also the *Samkhya* and the *Vaisesika* systems) of five steps or propositions.

The three-membered syllogism of the *Advaitins* has two alternate forms as shown below.

FORM I

Proposition to be proved (*Pratijna*)	: The hill has fire.
Reason for this (*hetu*)	: Because it has smoke.
Example (*Udaharana*)	: Whatever has smoke has fire such as a kitchen.

FORM II

Example (*Udaharana*)	: Whatever has smoke has fire such as a kitchen.
Application (*Upanaya*)	: The hill has smoke.
Conclusion (*nigamana*)	: Therefore the hill has fire.

The second syllogistic form of *Vedanta* resembles that of the Western logic which is noted below.

Major premise	:	Whatever has smoke has fire.
Minor premise	:	The hill has smoke.
Conclusion	:	Therefore the hill has fire.

In the two syllogistic forms of *Vedanta*, cited above, there are altogether five propositions.

The *Nyaya* syllogism comprised all these as illustrated below :

1.	Proposition to be proved (*pratijna*)	:	On yonder hill there is fire.
2.	Reason for this (*hetu*)	:	Because there is smoke.
3.	Universal proposition supported by an instance (*Udaharana*)	:	Wherever there is smoke there is fire, as in the kitchen hearth.
4.	Application of the Universal Proposition (*Upanaya*)	:	On yonder hill there is smoke which invariably goes with fire.
5.	Conclusion (proved) (*nigamana*)	:	Therefore on yonder hill there is fire.

In the *Advaitins* view the first three steps or the last three are adequate for the purpose.

Corresponding to the major term, the minor term and the middle term of Western logic, there are in Indian logic the *Sadhya* and *paksa* and the *hetu*. In the above three forms of syllogism (both *Advaitins* and the *Naiyayikas*), *Fire* is the *sadhya* (major term), the thing to be inferred. *Hill* is the *paksa* (minor term), the subject or that in which the thing is inferred. *Smoke* is the *hetu* (middle term) the reason or the ground of inference. The *hetu* is also called *sadhana*, the means of inference, the *linga*, the mark or sign that indicates the presence of fire on younder hill.

4. The Five Membered Syllogism of the Nyaya—Naturalistic Syllogism

The Five Membered Syllogism has been called the Naturalistic Syllogism as distinct from the somewhat Artificial Syllogism of Aristotle. This is the observation made by the Italian philosopher Croce. What he means is that it is in the form of a dialogue between two persons. Some one makes a statement which takes you rather by surprise. It is something unexpected, something for which you are not prepared. The first proposition called *Pratinja on yonder hill there is fire,* is intended to rouse our curiosity.

The moment you hear that there is fire on yonder hill, you rub your eyes and ask what the matter is. When you are told that there is fire on yonder hill, you express a little concern and in a challenging tone you ask for proof.

The next proposition, *hetu* furnishes the proof. There is smoke on yonder hill and this is the reason (*hetu)* for the assertion that there is fire on yonder hill. But you fail to see the connection between smoke and fire. You exclaim "True, I see the smoke even as you do. But what is the connection between smoke and fire?" In answer to this question the man says that wherever there is smoke, there is bound to be fire as in the kitchen hearth (*Udaharana)*. You interject saying that it is too tall a statement far too sweeping, and that it does not improve matters. Instead of speaking of a special reference to the smoke and fire on younder hill, the man know speaks of all imaginable cases of smoke and fire. Such a general statement does not easily carry conviction. To set your doubts at rest, the man calls pointed attention to the case of kitchen hearth, where a column of smoke is seen to rise as soon as the fire is lighted. This concrete example goes a long way with you.

But there is still a lurking doubt in your mind about the genuiness of the smoke. The whole conclusion depends upon the presence of smoke on yonder hill. "What *!* If it is not real smoke but mist or water vapour over hanging the hill."

You would like to be assured on this point. The man gives the categorical reply that on yonder hill there is the smoke that is always concomitant with fire *(Upanaya)*. After this assurance there is no room for any further doubt. You can no longer resist the conclusion (*nigamana*). It becomes inevitable. Therefore the original conclusion is reaffirmed after a very careful consideration for the whole question. In this miniature debate we find only the answers given and questions are suppressed. (According to some old *Naiyayikas*, there are ten members or *avayavas* of an inference.) But we can easily supply them and then we are able to see how the arguement proceeds step by step, meeting all objections, till the inevitable conclusion is reached.

5. Critics of the Five Membered Syllogism

The *Mimmasaka* rejects the *Naiyayikas* five membered inference on the ground that it involves unnecessary repetition. In an inference only three propositions are necessary neither more nor less. The *Advaitins* agree with the *Mimamasakas* on this point and say that the fourth proposition is redundant and that the fifth step in the syllogism is also unnecessary. The *Buddhists* maintain that *pratijna* is unnecessary and that only two propositions should be stated. Besides these, a general criticism has been advanced against the so called anomalous structure of the third proposition.

6. Nyaya Syllogism—Defended

The critics of the *Nyaya* Syllogism generally concentrate on three points :

(a) The conclusion appearing at the beginning and again at the end;

(b) The somewhat anomalous structure of the third proposition; and

(c) The juxtaposition of all the three terms in the fourth proposition.

The *Naiyayikas* have met all these objections squarely and fairly.

(a) *The conclusion appearing at the beginning and again at the end:* Critics point out that it is bad economy to state the same proposition twice over the syllogism. The law of parsimony requires that we shall have the minimum number of assertions in the syllogism. Not only should we strictly exclude everything that is irrelevant but also everything that is in the nature of repetitions. Disciplined thinking requires only the major points for its guidance. The Three Membered Syllogism is held upto us as the model. Judged from the stand point of Three Membered Syllogism, *Nyaya's* Syllogism appears somewhat loose and rambling and not possessing the brevity that is the characteristic of scientific thinking.

This criticism has already been answered in a way. The Five Membered Syllogism has been described as the Naturalistic Syllogism. It is intended to take a man step by step till he is able to see for himself that the conclusion is inevitable. To direct his thoughts along the proper groove, the conclusion (to be proved) must be stated at the beginning. Unless the starting point is indicated it is difficult for a man to collect his thoughts and direct them along the required channel. The essential point is that, according to the *Nyaya* view, the man to whom the syllogism is addressed is a vital partner in the game. He cannot remain passive and allow a conclusion to be drawn for him by someone else. As we have already said, it is a dialogue or a debate. It takes two people to make a debate. If it is granted that the two participants are to co-operate in an active manner, then it is quite necessary that one should make a statement in order to provoke the other man to think. Hence it is quite necessary to state the thesis at the outset. This is the way in which we start a discourse on any subject. The conclusion that we want to prove is stated at the outset in order that our hearers may fall into the mood, collect their thoughts and direct them.

The conclusion appearing at the end is not a mere repetition, it is not superfluous. On the other hand it serves a

very useful purpose. We reaffirm the original proposition after a very careful consideration of all the aspects of the question. The original proposition *(pratijna)* is abstract and it becomes concrete when we restate after weighing all the pros and cons of the question. Thinking which is set on foot by the original assertion has now completed itself. It has come a full cycle. The starting point and the end may look the same superficially speaking but there is a world of difference between an abstract statement and a concrete assertion. The intervening propositions make all the difference. The three members syllogism is (including that of Aristotle) held upto us as the model. A careful consideration will show that the Three Membered Syllogism, especially that of Aristotle, leaves many gaps, takes many things for granted and expects the hearer not to have any question of his own. In its anxiety to be brief, it has sacrificed clarity. It does not enable the other party to actively co-operate in the game. It does not contemplate the possibility to doubts arising in the mind of the listener ; it is more artificial than natural. On the other hand, the *Nyaya* Syllogism gives the other party free scope to come out with his doubts and objections and it tries to meet them squarely and fairly. When all the objections have been met, there is nothing that the listener can do but to give his whole-hearted assent to the conclusion. The Five Membered Syllogism is, therefore, self-sufficient. It is complete in itself holding all the elements in stable equipoise. It has wholeness which dispenses with a before and an after.

(b) *The somewhat anomalous structure of the third proposition.:* Now we come to the somewhat anomalous structure of the third proposition known as *Udaharana.* It consists of a general statement and a concrete example. Wherever there is smoke, there is fire as in the kitchen hearth. It is rather curious that a concrete example should be tackled on the statement of a law. Since the structure is somewhat anomalous scholars began to doubt whether the two parts had been there from the beginning.

Professor Kuppuswami Sastri takes the view that the proposition as a whole has been there from the beginning and

that neither the general statement nor the concrete example is, a later addition. He refers to *Gotama's Nyaya Sutras*, where he says that he is following the old tradition. From the earliest days, therefore, the third proposition must have consisted of the general statement as well as the concrete example. There are two good reasons in support of this view :

(i) It indicates that universal propositions are derived from the study and analysis of particular instances. The universal proposition which is so necessary for the Deductive Syllogism comes from concrete instances. Any syllogism presupposes inductive analysis of particular instances. The third proposition as it stands, emphasises the close and inseparable relation between Induction and Deduction. If the inductive basis of deductive reasoning has been treated by the Naiyayikas as an intergral part of a complete syllogism. It must be accepted that the *Udaharana* comprises both the parts viz., the part representing *Vyapti* and the part referring to a typical instance. The logic of *Nyaya* seeks to combine discovery and proof. The Nyaya Syllogism is such a harmonious blend of Induction and Deduction as ensures the safe progress of thinking on right lines.

(ii) Constant reference to things as they are to the facts of life, is the only effective check against wild and fantastic general propositions. The third proposition as it stands reminds us of the need to be constantly checking of our generalization in the light of the realities of life. Because of these two excellent reasons the *Nayayikas* choose to state the general proposition in the manner he has done. Therefore, there is no anomoly in its structure.

(c) *The Juxtaposition of all the three terms in the fourth proposition :* Criticism has also been directed against the fourth proposition where all the three terms are brought into relation. Critics point out that this step is unnecessary as the middle term has already played its part. In the second proposition we have the middle term in relation to the minor and in the third proposition we have the middle term in relation to the major.

The mediation is affected and nothing stands in the way of the minor and the major terms being brought into relation in the conclusion. And the appearance of the middle term in combination with the minor and the major term is not only superfluous but also a positive hindrance. It has been compared to the fifth wheel of the coach which proverbially retards motion and not accelerate it.

We have now to examine this criticism. Evidently the criticism is made from the stand point of the three membered, Aristotelian syllogism where there is nothing corrseponding to the fourth proposition. In Aristotle's syllogism (as in the three membered) we have two premises and a conclusion. In the major premise, we have the middle term in relation to the major term and in the minor premise, we have the middle term in relation to the minor term. But there is always a doubt lurking in our minds whether the conclusion is inevitable. For if the middle term is used in one sense in the major premise and in another sense in the minor premise the fallacy of ambiguous middle will arise. It is clear therefore that there should be absolutely no doubt or suspicion about the middle term. The conclusion depends upon the middle ground. To remove the last trace of doubt, it is desirable to affirm that the middle term which appears in relation to the major term is the same as the middle term that is used in relation to the minor. This new affirmation will certainly take the form of a proposition in which all the three terms will appear. Unless such an assurance is given the conclusion will not arise as a matter of course. When we are given the assurance that the smoke that is visible on yonder hill is not mist or water vapour but the smoke that goes with fire, there is nothing for us to do but to give our assent to the conclusion that there is fire on yonder hill. It is not even a case of giving our assent to it. On the other hand, it brings the major term very near to the minor term. It has, therefore, rightly been called *Upanaya* which literally means 'bringing closer together.'

7. Terms

Though there are five propositions in the *Nyaya* Syllogism, as we have seen already, there are only three terms.

(a) The hill—the minor term—*paksa.*
(b) Fire—the major term—*sadhya* and.
(c) The presence of smoke—the middle term—*hetu.*

The example that is given at the end of the third proposition is called *sapaksa.*

In the *pratijna,* we have *paksa* in relation to the *Sadhya* ; in the *hetu* we have the *paksa* in relation to the *hetu* ; in the *udaharana* we have the *hetu* in relation to the *sadhya ;* in the upanaya we have *paksa* and *hetu* and *sadhya* brought into relation and lastly in the *nigamana* we have *paksa* in relation to the *sadhya.*

8. Vyapti—The Ground of Inference

(a) *Vyapti* is the logical condition of inference. In an inference our knowledge of the *Sadhya* or major term as related to *Paksa* or minor term depends on the knowledge of *VYAPTI* between the middle term and the major term. That there is fire in the hill is a conclusion which we can justify only if we know that there is an invariable concomitance between hill, smoke and fire. This relation of invariable concomitance between the *hetu* and the *sadhya* or the middle term and the major term of inference is techincally called *Vyapti* ; and it is regarded as the logical ground of inference. Every inference is thus logically dependent on the knowledge of *Vyapti.* Hence the questions we have to consider here are : (1) What is *Vyapti ?* and (2) How is it *Vyapti* known ?

(i) What is Vyapti ?

The term *Vyapti* literally means pervasion, and lays stress on the universal character of the relation kept in view. The phrase universal connection brings out exactly the meaning of the term *vyapti.* In early *Nyaya* literature, the term *Avinabhava* is frequently used as the equivalent of *vyapti.* This term *avinabhava* brings into prominence the invariable character of the relation kept in view. The two concepts, universality and invariableness imply each other. But they are not

identical. We may say that *vyapti* relation turns upon invariability and universality.

Let us elucidate the nature of the *vyapti* relation by taking a concrete example. We say all cases of smoke are cases of fire. This implies that there is an invariable and universal relationship between smoke and fire or between *hetu* and *sadhya*; that what is implied in this relationship is that where there is smoke there is fire, or where there is no fire, there is no smoke. It would be wrong to say that when there is no smoke, there is no fire, or where there is fire, there is smoke. The reason is that smoke and fire are not co-extensive terms i.e., they are terms of unequal extension. Smoke has a narrower denotation than fire. Commonsense shows that it is possible for fire to exist independently of smoke. Live coals, a red hot iron ball and clear flame are instances of fire without smoke. But we cannot think of smoke independently of fire. If we represent smoke and fire by two circles, the circle representing smoke will be the smaller one contained within the circle of fire. It will be seen that fire is present in the circle represented by smoke as well as outside it. Fire, therefore, is the pervader of the *Vyapaka* while smoke is the pervaded or *Vyapya.* We can argue from the presence of the *Vyapya* (smoke) to the presence of the *Vyapaka* (fire) or from the absence of the *Vyapaka* to the absence of the *Vyapya.* In other words, in cases of *Vyapti* between terms of unequal extension (such as smoke and fire or between humanity and mortality) we cannot proceed from the absence of the *Vyapya* to the absence of the *Vyapaka* or from the presence of the *Vyapaka* to the presence of the *Vyapya.*

A *Vyapti* between terms of unequal extension such as smoke and fire, men and mortals, is called *Asamavyapti* or *Visamavyapti*. And it is a relation of non-equipollent concomitance between two terms, from one in which we may infer the other, but not vice versa. As distinguished from this, a *Vyapti* between two terms of equal extension is called *Samavyapti* or equipollent concomitance. Here the *Vyapti* holds between two terms which are co-extensive so that we

may infer either of them from the other. **Thus there is a** *samavyapti* between cause and effect, substance and attribute.

The *vyapti* between the middle and major terms means generally a relation of co-existence (*sachaacarya)* between the two; e.g. Wherever there is smoke, there is fire. However, every case of co-existence is not a case of *Vyapti*. Thus all the children of a certain father may be dark. But this does not mean that there is *Vyapti* or a universal relation between a particular parentage and dark complexion. In many instances fire may co-exist with smoke. Still there is no *Vyapti* or universal relation between fire and smoke, since there may be fire without smoke. The reason is that in such cases the relation of co-existence is dependent on certain conditions (*Upadhi)* other than the terms related. Thus the darkness of complexion is determined by certain physiological conditions and the presence of smoke in fire is conditions by moisture in the fuel. Hence we are to say that *vyapti* is the relation of co-existence between the middle and major terms which is independent of all conditions (*Upadhis*). *Vyapti* is an invariable and unconditional relation of concomitance between the middle and major terms.

Vyapti as the logical condition of inference, may be defined either positively or negatively. Positively speaking, *vyapti* is the uniform existence of the middle term in the same locus with the major term such that the major is not absent in any locus in which the middle term exists. *Vyapti* has been negatively defined as the non-existence of the middle term in all the places in which the major term does not exist. These two definitions of *vyapti* give us two universal propositions, one positive and the other negative, e.g. all cases of smoke are cases of fire; and no cases of non-fire is a case of smoke. This means that the *vyapti* which is the ground of inference may be either affirmative (*anvaya*) or negative (*vyatireka*)—*Anvaya Vyapti or Vyatireka Vyapti.*

(ii) How is Vyapti known ? (the ascertainment of Vyapti)

What is the means or the method of knowing *Vyapti*? How do we pass from particular cases of the relation between smoke

and fire to the universal proposition all cases of smoke are cases of fire? This is the problem of Induction which is not separately treated in Indian logic, but is made a part of the General Theory of Inference.

We know already that it is experience that enables us to draw universal proposition. The concrete instance of the kitchen hearth that comes at the end of the third proposition is intended to remind us of this fact. It is clear therefore that we have to take into account concrete and particular instances of a phenomenon before we generalise.

But here the *Carvaka* philosopher interposes an objection. If we take only a few instances into consideration clearly we have no right to generalise for there is no guarantee that what is true of the observed instances will also be true of the unobserved ones. If, on the other hand we take all instances into account, there is no need for inference at all. For we know all that we require to know; when everything is known, there is nothing to infer, i.e. the conclusion is already contained in the premise. Having stated this formidable objection, the *Carvaka* philosopher goes on to add that the great logical elephants are caught in a quagmire, not able to proceed further, nor to retrace their steps. Evidently he feels that the knock-out below has been given to all talk of inference as a *pramana*.

It will be remembered that a very similar objection was brought by J. S. Mill against the Theory of the Syllogism. He said that the conclusion was already contained in the major premise. Let us take a typical syllogism.

All men are mortal

Socrates is a man.

Therefore Socrates is mortal.

Mill says that the conclusion, 'Socrates is mortal', is already contained in the major premise, "All men are mortal". It is of no use pleading that the particular case of Socrates was not taken into account. Mill would then say that we had no right to argue from the known to the unknown. If, on the

other hand, we claim to have taken all instances into account, then the case of Socrates is known before hand and there is no need for inference. In other words Mill denies that all inference lies through a universal (*vyapti*) and states that all inference is from particular to particular. And he says that if inference lies through a universal, it commits the fallacy of petitic principle (*Siddhasadyata*).

Mill's objection was answered by later idealistic logicians, especially F. H. Baradely. The substance of the answer is that general propositions are not reached by the mere counting of instance but by analysis. The analysis reveals inner connections between humanity and mortality. The moment we perceive this connection we proceed to unify it. If it stands the test of verification, then we state it in the form of a universal proposition. 'All men are mortal'. This universal proposition is that applied to particular cases. As the result of the application we are not only in a position to bring the particular cases (Socrates) under a generalisation but also to realise the richness of meaning contained in the generalisation. Inference always proceeds through the universal relation. Mill is wrong in supposing that inference is from one particular to another particular. Indian logicians gave almost the same answer to *Carvakas* objections of inference, *Annambhatta* says that the mere number of instances, what he calls *Bhuyo Darsana*, is futile and serves no useful purpose. A general proposition will not become stronger merely because we have observed two hundred or even 20,000 instances of the same type. A few typical study of instances will serve the purpose provided we know how to study them. But the question still remains how can a universal proposition be established on the basis of limited observation? How can we ascertain or determine the invariable concomitance between *hetu* and *sadhya ?* In short how is *vyapti* known ?

The *Nyaya* method of ascertaining *vyapti* consists of four steps namely *anvaya*, *vyatireka*, *vyabhicaragraha* and *tarka*.

Anavya is a uniform (uncontradicted) experience of two things togetheir i. e. their co-presence, *vyatireka* is th uniform

experience of their co-absence. These two steps, *anvaya* and *vyatireka*, taken together correspond very well to Mill's Joint Method of Agreement in the presence and absence. Thirdly, we do not observe any contrary instances in which one of them is present without the other *vyabhicaragraha*. That is *vyabhicaragraha* is the non-observation of any contradictory instance. We always observe that wherever smoke is present, fire is also present. We never observe a case in which there may be smoke without fire. From the observed double agreements of smoke and fire in their presence and absence, together with the non-observation of any exception the *vyapti* between smoke and fire is known. In this process such irrelevant conditions (*upadhis*) as may vitiate the *vyapti* are eliminated (*upadhinirasa*) : because when smoke and fire are observed repeatedly under varying circumstances the conditions which are unessential and hence non-recurrent, are gradually detected and left out. If even after this there remains any doubt regarding the uncondionality of *vyapti*, it is removed by *tarka*.

Tarka is an argument based on the inconceivability of the opposite. It corresponds to the *reduction and absurdum* in western logic. *Tarka* is defined as a method of removing doubt regarding the validity of a proposition by first assuming the truth of its contradictory and then showing that such an assumption leads to an absurd conclusion. In the given illustration the assumption is made that there may be smoke in the absence of fire. This is a absurd proposition ' some cases of smoke are not cases of fire ' —and is the contradictory of the vyapti 'all cases of smoke are cases of fire' -(Proposition A). The absurdity, pointed out, by the *Naiyayikas*, in this assumption consists in its being contradictory to the law of causation and thus the *vyapti* is indirectly confirmed. However this reasoning is fallacious because it assumed the Law of Causation.

The *Naiyayikas* are conscious of the fact that the above methods are not the proof of the absolute validity of *vyapti* because inspite of the most careful search of irrelevant conditions the possibility of a contradictory instance making its appearance at some future times cannot be completely ruled out. So the *Naiyayikas* assume a kind of perception called

'*samanyalakshna*' in which it is said, we directly become aware of all the past, future, and present instances of a class through its universal. When we perceive fire and smoke, we also perceive the universal fireness and smokeness and through this latter perception, we perceive all the actual and possible insatances of fire and smoke. Thus we have a direct knowledge of *vyapti* between them in the form- ' All cases of smoke are cases of fire '. But we may reject *Nyaya's* theory by saying that *samanyalakshna* is not a fact of experience but only a hypothesis. Again, the *Naiyayika* by assuming *samanyalakshna*, take that which is to be proved as the proof of what is not borne out by facts. Hence it is better that instead of trying to secure the absolute validity of *vyapti* (as Nyaya tries to do) we are satisfied with its empirical validity.

(9) Classification and Logical Forms of Inference (Nyaya)

(a) According to one classification, Inference is of two kinds—*svarthanumana and pararthanumana* - i. e. *anumana* for oneself and *anumana* for others-this we have discussed already. The five membered syllogism comes under *pararthanumana*.

(b) According to another classification, Inference is said to be of three kinds namely, *purvavat*, *sesavat*, and *samanyatodrasta*.

A *purvavat* inference is defined as that in which we infer the un-perceived effect from a perceived cause. When we perceive dark and heavy clouds, we infer that rain will follow (from cause to effect).

A *sesavat* inference is that in which we infer the unperceived cause from a perceived effect. We perceive a river in floods and we infer that it should have rained heavily in the place through which the river is flowing (effect to cause).

A *samanyatodrasta* inference is one in which the *vyapti* between the major and the middle terms, does not depend on any causal uniformity but on certain points of similarity between different objects of experience. When seeing that Devadatta's change of position is preceded by his movement, we infer the sun's movement from its change of position in the sky. The inference is *samanyatodrasta*.

EXERCISES AND QUESTIONS

Exercises (Part A)

I. Give the logical characteristics of the following:

(1) Son.

(2) Blind.

(3) Non-Hindu.

(4) The Himalayas.

(5) Forgiveness.

(6) Ball.

(7) The Indian Navy.

(8) 2nd Tamilnadu Battalion NCC.

(9) Lok-Sabha.

(10) Alien.

(11) Unfortunate.

(12) Fairness.

(13) Jury.

(14) Cheerfulness.

(15) Hollywood.

(16) Inferiority.

(17) Square-foot.

(18) Amphibian.

(19) The first day of the month.

(20) Planet.

(21) Flock.

(22) Greenness,

(23) Disciple.

(24) Dishonest.

(25) The White House.

(26) Intelligible.

II. Classify the following terms under one or more heads Singular, General, Concrete, Abstract of Collective:

(1) Library.

(2) Rationality.

(3) Beauty.

(4) The Madras Regiment.

(5) The United Nations.

III. Point out the logical characteristics of the subject in the following propositions:

(1) The Prime Minister of India is from the Janata Party.

(2) The Prime Minister of India has to be the leader of the Lok-Sabha.

(3) All these books will fill a small book-case.

(4) All these books can be read in a day.

IV. Indicate whether the subject term in the following propositions is used collectively or distributively:

(1) The students surrounded the building.

(2) The students filled up their examination forms.

(3) The jury pronounced the verdict "Not Guilty."

(4) An army consists of brave men.

(5) Few men are rich.

V. Arrange the following terms in the order of Increasing Connotation :

College, Vivekananda College, College of Arts, Educational Institution, College of Technology, Institution.

VI. Take a paragraph or two from the news column of a daily newspaper. List the nouns that could serve as terms; then classify them as Singular, Abstract, etc.

VII. Arrange the following terms in the order of Increasing Denotation:

(1) Substance, organism, vertebrate, quadruped, elephant, animal, Indian elephant.

(2) Pilot pen, fountain pen, Japan Pilot pen, Indian Pilot pen with gold cap, Japan Pilot pen with gold cap used by our principal, stationery, pen.

VIII. Arrange the following terms under the headings—Singular, General and Collective:

The Governor of Tamilnadu, The Present Chief Minister of Tamilnadu, The Chief Minister's Relief Fund, Air India, The queen bee, Bee, The queen bees, Ladder, European, Pallavan, The First-Pallava King, Pallavan transport, Shakespeare, The Kalidasa of England, The Indian Machiavelli.

IX. Point out, giving reasons, the predicables in the following:

(1) This tree is a tamarind.
(2) Hydrogen is the lightest known body.
(3) Men are progressive animals.
(4) Mangoes are fruits.
(5) Valmiki is the author of Ramayana.
(6) An umbrella protects a man from the sun.
(7) Deepavali comes but once a year.
(8) Diamond is a form of carbon.
(9) Spiders have eight legs.
(10) Ice floats on water.
(11) Man is a biped.
(12) Man is a biped who wears pants.
(13) All Negroes have snub-noses.

(14) Some figures are circles.

(15) Some figures are squares.

(16) The tiger is a carnivorous animal.

(17) A cow has four legs and a tail.

(18) A library is a collection of books.

(19) Knowledge is power.

(20) Parallel lines are equidistant.

(21) Two straight lines cannot enclose a space.

(22) John has cropped head.

(23) Gopal is black.

(24) The orange is yellow.

(25) A spaniel is a dog for sport.

X. Examine the following definitions :

(1) Life is the opposite of death.

(2) A college student is a man on the rolls of the college.

(3) Logic is a mental science.

(4) A musical comedy is a dramatical representation with a happy ending.

(5) Life is the operation of vital forces.

(6) Matter is something we know not what.

(7) A horse is a grass eater.

(8) A table is an article of furniture.

(9) A table is one on which I am now sitting on.

(10) Man is a featherless biped.

(11) A horse is not a ruminant.

(12) A spinster is an unmarried woman.

(13) Work is the salt of life.

(14) Ambassadors are men sent for lying abroad.

(15) Music is an expensive noise.

(16) Parallel lines are lines that do not intersect in plane.

(17) To eat is to perform successively and successfully the functions of mastication, humectation and deglutition.

(18) Paradox is the passion of thought.

(19) Glass is something you can see through.

(20) Life is a tale, told by an idiot, full of sound and fury, signifying nothing.

(21) A professor is a student who forgot to graduate.

(22) Majority is plurality.

(23) Man is a laughing animal.

(24) Lion is the king of beasts.

(25) Governor is one who governs.

(26) A congressman is a khaddar wearer.

(27) Child is the father of the man.

(28) A moral man is one who is not immoral.

(29) Dyspepsia is indigestion.

(30) A curve is a line always changing its direction.

(31) A lie is a terminological inexactitude.

(32) Architecture is frozen music.

(33) A bachelor is an unmarried male person.

(34) Law is the backbone of order.

(35) Fine is a pecuniary mulet.

(36) Philosophers are the cream of mankind.

(37) A net is a lot of holes tied together by a string.

(38) Non-combatant is a man who does not fight.

(39) A King is a royal person.

(40) A pump is a water raising machine worked by a handle.

(41) A widow is a woman who has lost her husband.

(42) A shepherd is a person who looks after sheep.

(43) A sheep is a kind of animal looked after by a shepherd.

(44) Grammar is the logic of language.

(45) Fifteen is five times three.

(46) Eccentricity is a peculiar idiosyncracsy.

(47) Painting is a visualised music.

(48) Fasting is a great weapon in the armoury of satyagraha.

(49) Fluency is an exuberance of verbosity.

(50) Common salt is a crystalline compound of sodium and chloride.

XI. Examine the following divisions :

(1) Books into bound and unbound.

(2) Tea into sugar, milk, tea leaves, and water.

(3) Friendship into love, devotion, affection and admiration.

(4) Husbands into lover-husbands, fault-finding husbands and henpecked husbands.

(5) Schools into public, private and Higher Secondary.

(6) Lands into desert, fertile and Government owned.

(7) Lines into straight and curved.

(8) Music into classical and film music.

(9) Metals into heavy, white and precious.

(10) Light into artificial, blue light, tube light and moon light.

(11) Indians into vegetarians and non-vegetarians.

(12) Indians into Bengalis, Tamilians, English-speaking and Congressman.

(13) Eccentricity is peculiar idiosyncracy.

(14) Students into men, women, and post-graduates.

(15) Examinees into well-prepared, ill-prepared, late-comers, and first-class men.

(16) Ladies, gentlemen, students and friends.

(17) Indians into North Indians, South Indians and Muslims'

(18) Library volumes into literature, history, philosophy, reference books and journals.

(19) Propositions into affirmative, universal and singular.

(20) Taste into sweet and bitter.

(21) Human beings into men and women.

(22) Zoo animals into swimmers, crawlers, climbers, monkeys and parrots.

(23) Indians into Hindus and Non-Hindus.

(24) Contents of books into prefaces, chapters and press opinions.

(25) Colleges into Affiliated and Constituent.

Exercises (Part B)

(I) Examination of Inductive Arguments :

In Induction we use the following methods : (a) Observation, (b) Explanation (in terms of a hypothesis or cause), (c) Enumeration and (d) Analogy. These methods should be used properly; otherwise there will be mistakes in our reasoning. Some of these methods, even though used properly, will give only probable conclusions, for example, Analogy and Enumeration. To help the reader to identify the method used in the arguments, to examine them carefully and to mention the fallacies (if any), the following points will be of some help:

(A) How to identify the method ?

(1) If the argument is based on the collection or observation of facts, the method used is Observation.

(2) If the argument is based on counting of instances (instead of analysis of them), the method used is Enumeration. Enumeration may be complete or incomplete. (a) If the argument is based on counting all the instances, the method used is Complete or Perfect Enumeration. (b) If the argument is based on counting a few instances, the method used is Incomplete or Simple Enumeration.

(3) If the argument states a hypothesis in an attempt to explain the facts observed, the method used is Explanation in terms of a Hypothesis.

(4) If the argument states a cause in an attempt to explain the facts observed, the method used is Explanation in terms of Cause.

(5) If the argument is based on points of resemblance (and comparison) between things, the method used is Analogy.

(B) How to examine the arguments ?

(1) If the method used is Observation,the argument will be a case of either (i) Scientific Observation or (ii) Non-observation or (iii) Mal-observation. (i) If the argument is based on objective and unbiased observation, it is Scientific Observation. (ii) If it is based on observation of insufficient data leading to careless or purposeful omission of facts—facts which ought to have been observed and taken into account it is a case of the Fallacy of Non-observation. (iii) If the argument is based on a wrong interpretation of an observed fact, it is an instance of the Fallacy of Mal-observation.

(2) If the method used is Enumeration, the argument will be a cass of either (i) Complete Enumeration or (ii) Incomplete Enumeration leading to a probable conclusion or (iii) Incomplete Enumeration leading to hasty generalization. (i) If the argument is based on complete enumeration of all instances, it is not at all Induction, for there is no analysis of the facts counted, there is no Inductive leap and no suggestion of a Hypothesis. (ii) If the argument is based on incomplete enumeration, the conclusion is either Probable or Hasty Generalzation. The conclusion will be probable only if it is based on counting a large number of sufficient instances. (iii) If the argument is based on instances which are neither sufficient nor typical and based on a hasty collection of data, it is an instance of the Fallacy of Hasty (or Illicit) Generalization.

(3) If the method used is explanation in terms of a hypothesis, the argument will be a case of either (i) Scientific Hypothesis or (ii) False Hypothesis or (iii) Barren

Hypothesis. (i) If the argument is based on a hypothesis which admits of verification and proof, it is a case of Scientific Hypothesis; (ii) If the argument is based on a hypothesis which on verification is found to be untenable, it is an instance of False (or Rejected) Hypothesis; (iii) If the argument is based on a hypothesis which does not admit of verification, it is a case of the Fallacy of Barren Hypothesis.

(4) If the method used is explanation in terms of a cause, the argument will be either a case of (i) post hoc ergo propter hoc or (ii) mistaking a condition for the whole cause or (iii) fallacy of false cause or (iv) fallacy of regarding the co-effects of a common cause as cause and effect.

(5) If the method used is analogy, the reasoning will be a case of either (i) Sound (or Valid) Analogy on (ii) Unsound (or invalid) or False Analogy. (i) If the points of resemblance are relevant to the conclusion inferred, and if the argument has not omitted important points of difference between the things compared, it is a case of Sound Anolagy leading to a highly probable conclusion; (ii) if the points of resemblance are not relevant to the conclusion or if important differences are ignored it is case of Unsound Analogy.

(C) How to restate the arguments ?

The following procedure will be of immense help in the identification and examination of the inductive arguments.

(a) Conclusion
(b) Evidence
(c) Method
(d) Criticism.

(D) Points to be remembered

(a) Most (not all) cases of non-observation are cases of hasty generalization. The difference between the two depends on our identification of the methods employed.

(b) If the argument proceeds from one to all (as for example from India to all countries), it is a case of enumeration leading to hasty generalization.

(c) If the argument proceeds from one thing to another thing, (i. e.,) from one to one, (for example from the case of China to the case of India) it is a case of analogy. The following table will be useful in identifying and examining the arguments.

METHOD	CRITICISM
I. Observation	(i) Scientific Observation (ii) Non-observation (iii) Mal-observation
II. Enumeration	
(a) Complete enumeration	Not at all induction
(b) Incomple'e enumeration	(i) Proble conclusion or (ii) Hasty Generalization
III. Explanation In Terms of Hypothesis	(i) Scientific Hypothesis or (ii) False Hypothesis or (iii) Barren Hypothesis
IV. Causal Explanation	(i) Post hoc ergo propter hoc (ii) Mistaking a condition for the whole cause (iii) Fallacy of false cause (iv) Fallacy of regarding the co-effects of a common cause as cause and effect.
V. One of Mill's Exprimental Methods	Appropriate to the method used
VI. Analogy	(i) Sound Analogy or (ii) Unsound Analogy

II. Model Exercises worked out :

Identify and examine the following arguments

(1) All the wicked men I know are prosperous. Therefore, there is no need to be virtuous.

Answer : Conclusion : There is no need to be virtuous.

Evidence : All the wicked men I know are prosperous.

Method : Observation.

Criticism : This argument commits the fallacy of non-observation. Here the unfavourable instances are omitted. The conclusion is based on the observation of favourable instances only. It is a case of ommission. Hence the argument is invalid.

(2) Whenever I travel in the train, I find the trees move in the opposite direction. So trees move.

Answer : Conclusion : Trees move.

Evidence : Whenever I traval in the train, I find the trees move in the opposite direction

Method : Observation.

Criticism : This argument commits the fallacy of mal-observation. Here a thing is observed but it is understood wrongly. The conclusion is based on the wrong interpretation of facts leading to the fallacy of commission. Hence the argument is invalid.

(3) Present day college students have defective vision. I just saw half a dozen of them and all of them wore spectacles.

Answer : Conclusion : Present day college students have defective vision.

Evidence : I just saw half a dozen of them and all of them wore spectacles.

Method : Incomplete enumeration.

Criticism: This argument commits the fallacy of hasty general zation. The conclusion is reached after counting a few instances which are neither sufficient nor typical. Hence the argument is invalid.

(4) I have gone through the calender of 1979 and I find that all the months of that year have between 28 and 31 days.

Answer: Conclusion: All the months of the year 1979 have between 28 and 31 days.

Evidence: I have gone throughthe calende of 1979.

Method: Complete Enumeration.

Criticism: The conclusion is based on exhaustive counting. Hence there is no leap from the known to the unknown. There is no analysis and no suggestion of hypothesis. Since the method does not possess any of the characteristics of Induction by scientific analysis, this method is not at all Induction.

(5) All the crows I have observed so far are black. Therefore all crows are black.

Answer: Conclusion: All crows are black.

Evidence: All the crows I have observed so far are black.

Method: Incomplete enumeration.

Criticism: The conclusion is probable and not certain. It is based on counting and not on the analysis of instances. It is at the mercy of a contrary instance. There is description but no explanation. The conclusion is merely a summation of observed particulars. Hence it is a collective and not a generic universal.

(6) The lunar eclipse is due to the serpent Rahu swallowing the moon,

Answer : Conclusion : The lunar eclipse is due to the serpent Rahu swallowing the moon.

Evidence : Not given.

Method : Explanation in terms of a hypothesis.

Criticism : This arguments commits the fallacy of barren hypothesis. Here the hypothesis that is suggested does not admit of varification and proof. Since consequences cannot be deduced from such a hypothesis, it is useless. Hence the argument is invalid.

(7) Planets without inhabitants is like a house without tenants. Therefore planets must be in habited.

Answer : Conclusion : Planets must be inhabited.

Evidence : A planet without inhabitants is like a house without tenants.

Method : Analogy.

Criticism : This is a case of unsound anology. Here the points of resemblance are not relevant and fundamental to the conclusion inferred. There are important differences between the things compared. Since the argument does not satisfy the conditions of a good analogical reasoning, it is invalid.

(8) I had a headache after a ride in the bus. Therefore bus travel was the cause of my headache.

Answer : Conclusion : Bus travel was the cause of my headache.

Evidence : I had it after a ride in the bus.

Method : Causal explanation.

Criticism : This is a case of post hoc ergo propter hoc. Here we attribute the effect to the immediatly preceding event. Since the argument has not taken into account negative and positive instances, the conclusion is invalid.

Identify and examine the following arguments:

(1) Judging by the cases of Socrates and Bertrand Russell, I can conclude that philosophers are never popular.

(2) An airplane is like a bird in that both have wings. Just as we travel by plane, it is possible and likely that Lord Vishnu travels by the bird, "Garuda".

(3) A, B, C are frail and are women. Therefore all women are frail.

(4) The Rain God was propitiated last month. So, we have good rains now.

(5) A Government is like a symphony concert in that both have leadership.

(6) Railway lines are not parallel. Look at them from a distance.

(7) Tuesday is an inauspicious day.

(8) Never refuse alms to a sannyasin. His curse may send you to hell.

(9) Price finds its level just as water finds its level. Therefore price control is unnecessary.

(10) Salt dissolves in water; sugar dissolves in water; Alum dissolves in water. Therefore all substances must dissolve in water.

(11) The sun goes from the east to the west as we plainly see.

(12) Earthquakes are due to the anger of the Gods.

(13) Men show their teeth while laughing; so the dog must be laughing when it shows its teeth.

(14) Lord Vishnu appeared as a dwarf to cheat King Bali. So no dwarf must be trusted.

(15) The Government permits imitation silk, imitation diamond, imitation ivory in trade. Why should not imitation coins be permitted in currency?

(16) The recent Indo-Pakistan War is due to the hand of fate.

17. Our college MPC section is a class of intelligent students, for all of them have scored more than 450 marks out of 600 in the S.S.L.C. Examination.

18. States must decay as individuals do.

19. Snow must be sweet because it is like sugar.

20. Prohibition failed in America. Therefore it is bound to fail in India.

21. Prohibition failed in India. Therefore it is bound to fail in all countries.

22. There can never be equality among men. Look at the five fingers.

23. Telegrams are unwelcome for they bring death news.

24. Brahmins must be vegetarians for I have seen many Brahmins who are vegetarians.

25. The earth is flat. Do we not see it to be flat?

26. Women are better politicians. Look at Smt. Indira Gandhi.

27. He was defeated and lost his deposit in the bye-elections for he filed his nomination paper during 'Rahukalam'.

28. Bald-headedness must be a sign of greatness because some of the greatest men are bald-headed.

29. The little boy infers that the sky is only as high as the tree at a distance for the sky seems to touch it.

30. I shall never believe in anybody's honesty in future, for I have been betrayed by my dearest friend.

31. All religions lead to God for do not all rivers fall into the sea?

32. All the disciples of Christ are Hebrews.

33. Whatever may be the cause of the riots in East Bengal, I am of the opinion that fate is the real one.

34. We should not dismiss our servants when they go wrong. We do not throw away our watches when they go wrong.

35. I have carefully gone through the entire list of members and find that they are all Hindus.

36. I know three persons who died after vaccination. So vaccination is fatal.

37. Do you not see smoke rising in the sky? Then how can you say that gravitation is true?

38. Krishna is laid up with a complicated kind of illness. The astrologer attributes the cause to the planetary positions in his horoscope.

39. Opium cannot be injurious for I have read in the papers of the death of a confirmed opium eater at the ripe age of ninety five years.

40. The number of deaths in Madras city per annum is greater than in Kumbakonam. Therefore Madras is unhealthier than Kumbakonam.

41. This patent medicine must be very effective for all the testimonials speak of the marvellous cures effected by it.

42. Some foreigners who came to India concluded that Indians are rich after visiting Bombay and Delhi where they saw fleet of cars on the road and well-dressed ladies in the party-houses.

43. Wars are caused by Satan.

44. There is a destiny that shapes our ends. That is why he was defeated in the Union Elections.

45. The wicked woman's evil eye fell upon the child. Therefore the child fell ill.

46. The bank clerk, whose cash balance is short, attributes the shortage due to the peculiar position of Saturn in his horoscope.

47. His family is only as large as mine and if he can own a car, why not I?

48. The people of this country seem to be in a hurry Look at the people in this hotel.

49. Our hospitals must have vacation like our schools and colleges.

50. Deceived by his own mother's morality Hamlet exclaims : "Frailty thy name is woman".

51. No wicked men are heroes in Indian Literature. All classics have been examined.

52. That town must be unhealthy for I know three people who live there and not one of them is in good health.

53. I see the sun rise and set every day. I therefore conclude that the sun goes round the earth.

54. The Asian countries do not deserve Independence. See what has happened in Burma and Indonesia.

55. A large number of birds have been examined and found to be without teeth. Therefore it is inferred that birds are without teeth.

56. If a country like Japan can establish a system of world trade, why can't India ?

57. Every plant, every beast, every man, in short every animal breathes. Therefore every living body breathes.

58. "Society has no more rights to expose its members to the dangers arising from the consumption of alcohol than a parent has to allow his children to play with a loaded revolver" (Dotterer).

59. Most of our politicians are successful men. They never went to college. Therefore college education is not conducive to success in life.

60. The rose is red in colour. It is cool to the touch. Therefore fire which is also red must be cool to the touch.

61. The lower animals feel pain just as we do.

62. Simla pact has been violated in spirit by Pakistan. Hence Pakistan will violate all pacts.

63. The power failure in India during this year is due to the failure of the Project Electrical Engineers to offer their prayers to Lord Varuna.

64. These splints cured John's broken legs. Therefore they will cure my broken heart.

65. He was defeated in the election because he was a writer whereas the voters were of other profession.

66. Fluent speakers are not profound thinkers. Look at Mr. K.

67. One day I walked under a ladder and immediately I had a fall. Therefore do not walk under a ladder.

68. Children are bright and interesting, but adults are dull and uninteresting. What has happened in the middle? Education.

69. Drink must be the cause of poverty, for most poor people drink.

70. The flood was due to the wrath of the Goddess, for it appeared immediately after she had been slighted.

71. The waving of the juggler's wand was the cause of the appearance of the snake, because the snake appeared the moment the juggler waved his wand.

72. When beggars die, there are no Comets seen; the heavens themselves blaze forth the death of Princes. There is therefore a necessary connection between the appearance of a Comet and the death of a Prince.

73. The whole of this street was inoculated. Yet some of its residents have died of cholera. Therefore, inoculation is no safeguard against the disease.

74. Recently there have been several cases of typhoid in the city. On investigation it was found that all of them were being supplied milk from the same dairy.

75. Whenever a cat crosses my path, I fail in my undertaking. Obviously the crossing of the path by the cat is the cause of my failure.

76. The bigger the city, the greater the number of crimes. The bigger the city, the greater the number of cinema theatres. Cinemas are the cause of crimes.

77. The proportion of inmates in our Mental Hospitals who can read and right is very high, from which we have to infer that education is among the causes of insanity.

78. India owes Its independence to the study of English for all the Indians political leaders know the language.

79. Did you see the Comet that appears in the Southern Sky? It must be a portent of a Third World War!

80. Who can doubt the efficacy of prayer and sacrifice seeing that within an hour of the termination of the worship in the temple, it began to rain in torrents?

81. The eating of mangoes is the cause of boils.

82. One of the sailors rescued wore an amulet, and this was no doubt the cause of his escape.

83. The only cause of the decrease of crimes is the abundance of food supply, for crimes increase with the growing scarcity of food.

84. Two small pieces of blanket, exactly alike in all respects except that one is coloured white and the other black, are placed on a block of ice. After a certain time it is found that the black piece has sunk deeper into the ice than the white one. Therefore it is concluded that black absorbs more heat than white.

85. Jupiter gives out more light than it receives from the Sun. What is the obvious conclusion and by what method is it reached?

86. Overdriven cattle, if killed before recovery from their fatigue, become rigid and putrefy in a surprisingly short time. A similar fact has been observed in the case of animal hunted to death, cocks killed in fight, and soldiers slain in the field of battle. Therefore it is concluded that severe exhaustion prior to death is the cause of rapid putrefaction.

87. When a coin and a feather are dropped simultaneously in the receiver of an air pump, the air being left in, the feather flutters to the bottom after the coin; but when the air is pumped out of the receiver, the coin and the feather, being dropped at

the same instant reach the bottom of the receiver together What is the apparent conclusion and by what method is it established?

88. Intermittent fever is found only in places where there are marshes even though they differ in every other respect. Therefore marshes are the cause of intermittent fever.

89. Poverty must be the cause of increase of population, for we find that all poor countries are thickly populated, while those that are rich have a scanty population. Further what is true of countries is also true of individuals. It is usually the poor who have big families.

90. Both mosquitoes and malarial fever have in certain parts of West Africa. India, Malaya and elsewhere, become much more since these districts have been well drained. Is malarial fever the effect of the presence of mosquitoes?

91. Whenever I take tea in the evenings I don't sleep. I find I am able to sleep well if I avoid taking tea. Obviously tea is the cause of my sleeplessness.

92. The scarcity of food grains in the country is due to the lack of facilities for transport, for we find that scarcity of food grains increases when difficulties of transport increase.

93. Countries that are industrialised like England and America increase in power. Therefore increase of industrialisation leads to increase in power.

94. The boys who take milk are healtheir than those who do not take it. Milk is therefore, a nourishing diet.

95. Worms do not possess any sense of hearing. They did not take the least notice of the shrill notes of a metal whistle which was repeatedly sounded near them; nor did they of the deepest and loudest notes of a basson; they were indifferent to shout if care were taken that the breath did not strike them. When placed on a table close to the keys of a piano, which was played as loudly as possible, they remained perfectly calm (Latta and Macbeath),

96. In all unhealthy countries the greatest risk of Malaria fever is run by sleeping on shore. Is that owing to the state o the body during sleep or to a great abundance of mosquitoes at such time? It appears certain that those who stay on board a vessel generally suffer less than those who stay actually on shore.

97. The length of the string determines the pitch of the note, for it is inversely proportional to the length of the vibrating string.

98. Drink must be the cause of poverty, for most poor people drink.

99. There is a disease called cretinism which produces a stunted condition of body and mind. In cases where the symptoms of the disease are present there is found to be an insufficient amount of secretion from the thyroid gland, and the less the secretion, the more pronounced the symptoms. When treatment with a preparation of thyroid is tried, the symptoms gradually disappear. If the treatment is stopped, the symptoms reappear.

100. Suppose there is a peculiar odour coming from the direction of the refrigerator. On investigation we find that the butter, meat, fruit and indeed each of the other articles in the box has an odour which cannot be identified with that we first perceived. The real cause, then, is outside the refrigerator. Further search reveals the presence of some decayed flowers lying in a nearby corner.

101. For many generations the people of the Isle of St. Kilda believed at the arrival of a ship in the harbour inflicted on the islanders epidemic colds in the head, and many ingenious reasons were devised why the ship should cause colds. At last it occured to somebody that the ship might not be the cause of the cold but that both might be effects of some other common cause and it was then remembered that a ship could only enter the harbour when there was a strong north-east wind blowing.

Questions

1. When is a term said to be (i) equivocal (ii) general (iii) negative (iv) connotative?

2. In how many different ways are terms distinguished n Logic? Illustrate your answer with examples.

3. (a) Distinguish between Concrete and Abstract terms.

   (b) Distinguish between Singular, General and Collective terms.

4. Give three examples of terms standing to one another in the following relations :-

   (i) Species and Genus, (ii) Species and Accidens, (iii) Species and Property (iv) Species and Differentia.

5. Give propositions predicating a Differentia, a Property, a Separable and an Inseparable Accidens of school boys.

6. Illustrate the five predicables with reference to the term, 'College'.

7. Explain clearly definition 'per genus et differentia'.

8. State and explain the requirement of a good definition.

9. State and explain the Rules of Logical Division.

10. Illustrate the fallacies of Cross Division, Incomplete Division and Overlapping Division by dividing, the class term 'army' into its constituent species.

11. Explain the following :

    (a) Division by dichotomy

    (b) Extra-logical divisions.

12. (a) What is the relation between Division and Definition?

    (b) Write brief notes on: Infima Species, Summum Genus, Differentia.

13. Explain the problem of Induction and indicate a solution.

14. What are the Postulates of Induction? Can they be proved?

15. State and illustrate the Stages of Induction.

16. Determine the Nature of Observation. Describe how Observation is related to hypothesis in Induction.

17. What is Observation? What are the merits of Observation?

18. Distinguish Observation from Experiment? What are the merits of Experiment?

19. What are the characteristics of Scientific Induction? How does it differ from Enumerative Induction?

20. What is Enumeration? Distinguigh between Complete and Incomplete Enumeration. What are the fundamental defects of the method of Enumeration? Does it have any value?

21. What is Analogy? Explain and illustrate the condition of a Valid Analogical Reasoning.

22. Define Hypothesis. Indicate how in the method of Hypothesis Induction and Deduction are closely related.

23. What is a Hypothesis? Describe the verification and proof of a Hypothesis.

24. What is Induction? Bring out the relation between Induction and Deduction.

25. What is the part played by Hypothesis in Induction? What are the tests employed for determining the value of a Hypothesis?

26. Name and explain the methods that you will use to study the following:

(a) To study the habits of ants in the garden.

(b) To study the stars during night by means of a telescope.

(c) To study the cause of the recent floods in the state.

(d) To study the effects of a poison.

27. What is the value of Analogy and what are its limitations as a Method of Explanation?

28. What is Hypothesis? What distinguishes it from a mere guess?

29. Show how Genuine Induction is to be distinguished from simple Enumeration of instances.

30. Explain and illustrate three of the most common fallacies specially associated with Induction.

31. What are the presuppositions involved in Inductive Reasoning? Explain.

32. Estimate the relative value of Enumeration and Analogy as aids to Inductive Reasoning.

33. How is a Hypothesis suggested, tested and established? Give examples.

34. The conclusion in a piece of Inductive Reasoning goes beyond the evidence. How do you justify it?

35. What are the formal grounds of Induction? Are they the products of Induction?

36. Distinguish between Fact and Theory. What are the stages in the inductive process?

37. What is the value of a number of instances in an Inductive Inquiry?

38. "The method characteristic of modern science is Inductive". Discuss.

39. Distinguish the terms Fact, Law, Hypothesis, Theory and Postulate.

40. What is the special function of Induction as distinct from that of Deduction ?

41. Distinguish the Law of Uniformity of Nature from the Law of Universal Causation and explain their relation to each other.

42. "The force of Analogy does not depend on the amount of the resemblance but on the character of the resemblance". Discuss.

43. What is the method of Concomitant Variations and for what purpose is it chiefly valuable?

44. What is the value of statistical statement from the point of view cf Induction, and what dangers beset their use?

45. State and illustrate the Method of Residues. What is its main function?

46. Explain and illustrate the Method of Difference in the determination of Causal Connection.

47. State and examine Mill's definition of Cause.

48. State and explain the Method of Agreement and compare it with Simple Enumeration.

49. What are Bacon's four idols and how far do they serve as a classification of the Fallacies of Induction.

50. Explain and illustrate :

(a) Plurality of Causes.

(b) False Cause.

(c) post hoc ergo propter hoc.

51. Explain and illustrate the Joint Method of Agreement and Difference.

52. "Mill's Inductive methods are all weapons of Elimination". Discuss.

53. What are the conditions to be satisfied before one can say that two things or events are causally connected ?

54. What are Mill's methods ? Give a general estimate of the name.

55. Name the experimental methods by which each of the following conclusions is arrived at:

(a) If a particular portion of the brain is removed, a particular part of the body is paralysed.

(b) The more a body is heated, the more it expands.

(c) Heat is the cause of the melting ice.

(d) One day in a Temple Hundi a hundered rupee note was found. The priest knew well that no members of the village would have done that. He remembered that he saw a stranger in the temple on that day. Therefore the priest concluded that he was the donor of the 100 rupee note.

56. What is *Anumana* ? what are different types ?

57. State and explain the Five-membered Syllogism of Nyaya.

58. What is *Vyapti* ? How is it ascertained ?

59. Discuss how the Vyaya Syllogism is a Naturalistic Syllogism.

60. What are the criticisms levelled against the Nyaya Syllogism ? How does the Nyaya meet them ?

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